Fourteenth Quarterly Progress Report

D6-44815-14

March 1982

ENVIRONMENTAL EXPOSURE EFFECTS ON COMPOSITE MATERIALS FOR COMMERCIAL AIRCRAFT

by Martin N. Gibbins

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LANGLEY RESEARCH CENTER
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Under Contract NAS1-15148

by

Boeing Commercial Airplane Company
P. O. Box 3707
Seattle, Washington 98124

FOREWORD

This report was prepared by the Boeing Commercial Airplane Company, Seattle, Washington, under Contract NAS1-15148. It is the fourteenth quarterly technical progress report covering work performed between January 1 to March 31, 1982. The program is sponsored by the National Aeronautics and Space Administration, Langley Research Center. Mr. Ronald K. Clark is the NASA Technical Representative.

This contract is being performed by the Advanced Structures Staff organization. Key personnel associated with the program during the reporting period and their area of responsibility are:

R. D. Wilson	--Program Manager
M. N. Gibbins	--Technical Leader
E. E. Peterson	--Materials
R. T. Cook	--Quality Assurance
J. S. Chen	--Chemical Analysis

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ENVIRONMENTAL EXPOSURE EFFECTS ON COMPOSITE MATERIALS FOR COMMERCIAL AIRCRAFT

M. N. GIBBINS
BOEING COMMERCIAL AIRPLANE COMPANY

1.0 SUMMARY AND PROGRAM STATUS

Progress during this quarter included testing of 3 year exposure specimens from the Honolulu exposure rack and completion of analysis on 3 year exposure specimens from Edwards AFB.

Radiographs of the Honolulu short beam shear (SBS) specimens have shown edge cracking caused by the final post exposure machining operation on these specimens. No apparent strength effect of observable cracking on specimen strength was found, however.

Unexposed SBS and flexure specimens stored for 3 years in a controlled environment were mechanically tested. Flexure strength values showed a drop in strength from 1 and 2 year results.

Results of testing to date indicate the primary environmental effect through 3 years of exposure is absorbed moisture. Short beam shear and ±45 tension specimens have been most sensitive with SBS losing strength and tension gaining strength with increased moisture content.

Activities for next quarter will include mechanical testing of 2 year exposure Weatherometer specimens, and dryout of selected specimens from the Weatherometer and from Honolulu for moisture content determination.

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2.0 INTRODUCTION

The introduction of any new material system into commercial aircraft structure requires that an information data base be available to the designer in such a form that one can accept the material as a viable alternate to the current material system in use. Composite material components on airplanes in scheduled commercial service have demonstrated a viable level of confidence in current design and fabrication methods. In spite of this, the long term durability of composites exposed to actual airplane operational environments represents a significant unknown in assessing the risk level for a production commitment to primary airplane structure.

This contract focuses on expanding the data base for composite materials' properties as they are affected by the environments encountered in operating conditions, both in flight and at ground terminals. It is well known that absorbed moisture will degrade the mechanical properties of graphite/epoxy laminates at elevated temperatures. Since airplane components are frequently exposed to atmospheric moisture, rain, and accumulated water, quantitive data are required to evaluate the amount of fluids absorbed under various environmental conditions and the subsequent effects on material properties. In addition, accelerated laboratory test techniques must be developed that are reliably capable of predicting long term behavior. The study will include a task to develop an accelerated environmental exposure testing procedure and to correlate all experimental results and compare with analytical results to establish the level of confidence for predicting composite material properties.

The overall program has a duration of approximately 11 years and is performed in three tasks as follows:

- Task I - Flight Exposure
- Task II - Ground Based Exposure
- Task III - Accelerated Environmental Effects and Data Correlation

Among the parameters to be investigated are: geographic location, flight profiles, solar heating effects, ultraviolet degradation, retrieval times, specimen types, test temperatures, and others. The experimental program includes in-flight and ground exposures of up to 10 years and will obtain mechanical, physical, and chemical data from about 17,000 specimens. A complete description of the program content was given in the first Quarterly Report (Reference 1). Other reports (References 2-13) have covered progress to date. The overall program is summarized schematically in Figure 2-1. The program schedule is shown in Figure 2-2. All tables and figures appear after the text.

3.0 DESIGN

No tasks currently active.

4.0 FABRICATION

No tasks currently active.

5.0 EXPOSURE AND TEST

5.1 Long Term Exposure and Test

A summary of the long term exposure status is shown in Tables 5-1 and 5-2. Southwest Airlines had not deployed their set of Kevlar specimens as of March 31, 1982. All of the other optional material specimens (AS1/3501-6 and Kevlar 49/F161-188) have now been deployed.

During this reporting period results were analyzed for the testing performed on 3 Year Edwards specimens. Three Year Honolulu specimens were removed from exposure on February 9, 1982 ~~1981~~, and returned to Boeing. Testing has been completed except for the dryout of selected specimens for moisture content determination. Summaries of the individual specimen strength and weight data appear in Appendix Tables A-1 through A-4. The individual specimens are designated with identifying characters found in the left hand column of the tables. These characters specify the material, specimen, type, and exposure condition. Figure A-1 describes the code used in the identifying characters.

Tables 5-3 and 5-4 give the results of the 3 Year Edwards specimen testing in terms of percent of baseline values and percent weight change. Some of the specimen weight loss during solar exposure can be attributed to solar degradation and erosion of surface paint. Figures 5-1 and 5-2 show the material moisture content through 3 years exposure as measured by coupon dryout. These figures show an inconsistent moisture level from year to year. The moisture levels may be a function more of season the specimens were removed from exposure than of exposure duration. The 1 year specimens were removed on February 12, 1980, during the season of highest relative humidity. The 2 year specimens were removed on October 14, 1980, closer to the hotter and dryer season. These specimens had probably lost moisture during the summer and had not yet gained back moisture equivalent to winter levels. The 3 year specimens were removed on November 25, 1981. This gave these specimens 42 days exposure extended farther into the more humid weather than the 2 year specimens.

An analysis showed comparable results. The analysis used a finite difference solution for Fick's one-dimensional diffusion equation. Temperature and relative humidity values from National Oceanographic and Atmospheric Administration (NOAA) data were used. Figure 5-3 shows the moisture content analysis results for an initially dry 12 ply T300/5208 laminate through 27,000

"exposure" hours at Edwards AFB. The analysis used temperature and humidity values measured starting October 30, 1958. October 30, 1978 was the day the ground rack arrived at Edwards, therefore the analysis begins at the same time of the year as actual exposure began. The initial moisture content on October 30 was assumed to be 0.2% by weight. This level represents a probable equilibrium level achieved under preexposure storage conditions.

The first 9000 hours (approximately 1 year) appears to be an initial equilibrating period. During the remaining time, shown in Figure 5-3, the moisture content seems to cycle with the seasons. The periods of low moisture content appear during or following the summer, and the periods of high moisture content appear during or after winter.

The measured moisture content values do not fall directly on the analysis plot, and there are several possible explanations for this. First, the temperature and relative humidity values used in the analysis are values actually measured at Edwards, and while they are believed to be representative of Edwards they are not the actual values during exposure of the samples. Information was not readily available from NOAA for the exposure period. Random differences may affect the results of either the analysis or the measurements.

Second, geometry effects are not considered. The analysis assumes an infinite twelve ply panel, while the measurements were made on shear exposure samples (see the Interim Report, NASA CR 3502, p. 18) which are twenty plies thick and contain a large percentage of edge. No treatment of edge effects is used in the analysis.

Third, solar effects and rain is not accounted for in the analysis. Rain wetting the surface of the specimens may increase the moisture content, while solar effects may heat the specimen surface and/or decrease the relative humidity in the specimen's immediate vicinity.

Fourth, the effects of surface paint is not accounted for in the analysis.

Fifth, results of the analysis depend on the values of the diffusion parameters. Measured values may vary depending on batch to batch variations, cure cycle variations, and exposure conditions. A variety of values are documented in Reference 14 for several different materials. The values used in this analysis have been used by Boeing in the past.

The analysis is used here mainly to show a predictable seasonal variation in moisture content of ground based graphite epoxy.

Short beam shear (SBS) strength has had an inverse relationship to moisture content in most testing to this point. A plot of the 1, 2, and 3 year exposure short beam shear strength should then resemble the inverted shape of the associated moisture content plot. Two of the three materials did follow this trend. Figures

5-4 and 5-5 show the lowest SBS strength for T300/5209 and T300/934 during the first exposure year when the moisture content was greatest. This trend did not apply to T300/5208 which, in general, experienced the greatest strength during the first year.

Flexure and tension specimen testing results, Figures 5-6 through 5-9, show that strengths are either above baseline values or by three years are on an upward trend. Figure 5-7 A and B show a positive relationship between moisture content and flexure strength as opposed to the negative relationships for SBS. Reductions in the upward flexure strength trends appear at year 2 when moisture content was lowest.

Compression strength is on a downward course as shown in Figure 5-10, although there are no other readily apparent trends. The scatter of values among the three materials after the first year of exposure in Figure 5-10B is reduced in the second and third years. Any dependency of compression strength on moisture content is not clear from this data. It should be noted that all T300/5208 specimens tested at high temperature experienced end grip tab failures rather than compression failures. In this case, the material strengths would actually be higher than the value shown.

The results of the 3 year Honolulu testing are given in Tables 5-5 and 5-6. X-ray radiographs were made of all short beam shear specimens before and after final machining. This machining is required because 3 specimens are exposed as one graphite epoxy strip, and must be divided. Radiographs were made with the specimens lying flat and with the specimens on edge as shown in Figure 5-11.

The radiographs revealed that after machining approximately 75% of the short beam shear specimens contained at least one crack. These cracks were revealed in the edge view radiographs. Table 5-7 contains a comparison of strengths between cracked and uncracked specimens. The cracks extend less than .1" in from the end unless otherwise noted. Short beam shear specimens not shown in Table 5-7 contained cracking in all three machined segments.

Comparing the strengths in Table 5-7 reveals that in three cases the cracked specimens were stronger than the uncracked specimens (lines 1, 6, and 7), and in three cases the uncracked specimens were stronger than the cracked specimens (lines 2, 3, and 5). In one case (line 4) there was no difference between cracked and uncracked specimen strengths. From these observations, it can not be concluded that the cracks have an effect on SBS strength.

Figure 5-12 shows the short beam shear strengths for specimens exposed at Honolulu and tested at room temperature. Concern has been expressed about the low strength value for the T300/5208 specimen exposed for 2 years (Figure 5-12A) which had only 52% of the baseline strength. The 3 year strength was 91% of baseline. It appears that the low 2 year strength was anomalous and not representative of environmental effects. Otherwise, the strengths appear to be stabilizing for all three materials. A

description of the analysis performed on the low strength 2 year specimen was included in Ref. 12.

The SBS results for specimens from Honolulu tested at 180°F are shown in Figure 5-13. These strengths also appear to have stabilized after 3 years of exposure.

Figures 5-14 and 5-15 show the results for flexure testing. While the specimens exposed at Edwards have experienced increases in strength, the Honolulu specimens have been generally decreasing in strength during the second and third years.

Figures 5-16 and 5-17 show the results for tension testing. The T300/5208 and T300/934 specimens respond similarly to the specimens exposed at Edwards, Figure 5-8. In Figure 5-16 the T300/5209 performance is well below the other two for Honolulu exposure. For the tension specimens tested at room temperature, Figure 5-17, all three materials respond similarly to each other and similarly to the Edwards specimens, Figure 5-9.

The results from compression testing were erratic, Figure 5-18, as were the results of the Edwards compression tests. As noted in Table 5-6, the 3 year value for the 180°F tested 934 compression test represents only one specimen as the other two experienced tab failure. Also, all three 5208 specimens tested at 180°F experienced tab failure.

5.2 Accelerated Laboratory Test

Flexure and SBS specimens of T300/5208, T300/5209, and T300/934 stored for 3 year time alone exposure were tested with the Honolulu specimens. Strength and weight change results appear in Table 5-8. Individual specimen strength and physical property data appear in Appendix Tables 5 and 6. One, two, and three year collected weight change, SBS strength, and flexure strength results appear in Figure 5-19, 5-20, and 5-21, respectively. The weight change trends show an initial drop during the first exposure period (1 year nominal). Most of the weight changes of subsequent exposure durations did not drop as sharply, and by the 3 year exposure had reversed the down trend. The T300/5209 material had actually gained weight after 3 years exposure.

These specimens have been stored in small desiccated jars during exposure. The desiccant is an indicating type which changes from blue to pink as it absorbs moisture, and it is replaced as needed. Assuming the change in weight is due to a change in the absorbed moisture level, and that the jars remained consistently dry through exposure. the 3 year specimens would have been expected to lose amounts similar to the 1 and 2 year specimens.

The short beam shear strength levels have been steady through the 3 year test. The flexure strengths were near the baseline values through two years, but experienced a drop for the third year.

ENVIRONMENTAL EXPOSURE EFFECTS ON COMPOSITE MATERIALS FOR COMMERCIAL TRANSPORT AIRCRAFT

- FIVE MATERIAL SYSTEMS
- LONG TERM GROUND & FLIGHT EXPOSURE DATA
- ACCELERATED LABORATORY DATA
- DURABILITY MODEL & ACCELERATED TEST PROCEDURES

TASK I FLIGHT EXPOSURE

- CONFIDENCE THROUGH LONG TERM EXPOSURE DATA
- INTERIOR AND EXTERIOR EXPOSURE ON THREE DIFFERENT AIRLINES FOR TIMES UP TO TEN YEARS
- OVER 5300 SPECIMENS

TASK II GROUND EXPOSURE

- CONFIDENCE THROUGH LONG TERM EXPOSURE DATA
- SOLAR AND NONSOLAR EXPOSURE AT FOUR DIFFERENT GROUND STATIONS FOR TIMES UP TO TEN YEARS
- OVER 5300 SPECIMENS

TASK III ACCELERATED ENVIRONMENTAL EFFECTS AND DATA CORRELATION

- BASELINE TESTING
- ACCELERATED TESTS TO LOOK AT THE EFFECTS OF TIME, TEMPERATURE, STRESS, MOISTURE, WEATHEROMETER, AND GROUND-AIR-GROUND SIMULATION
- OVER 4300 SPECIMENS
- ANALYTICAL MODEL FOR DURABILITY PREDICTION
- RECOMMENDED ACCELERATED TEST PROCEDURES FOR EVALUATING ENVIRONMENTAL RESISTANCE

Figure 2-1. Program Content

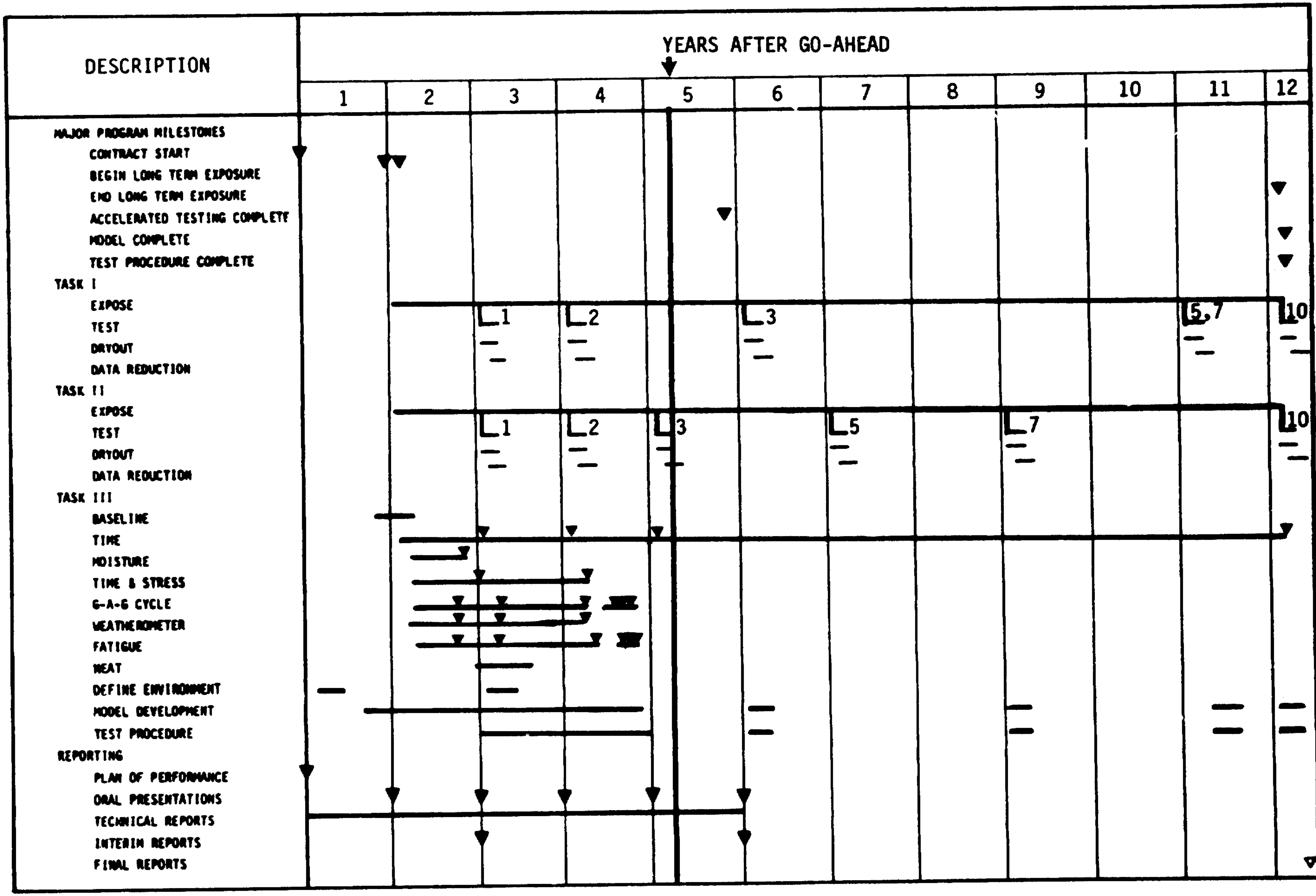

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Figure 2-2. Program Schedule

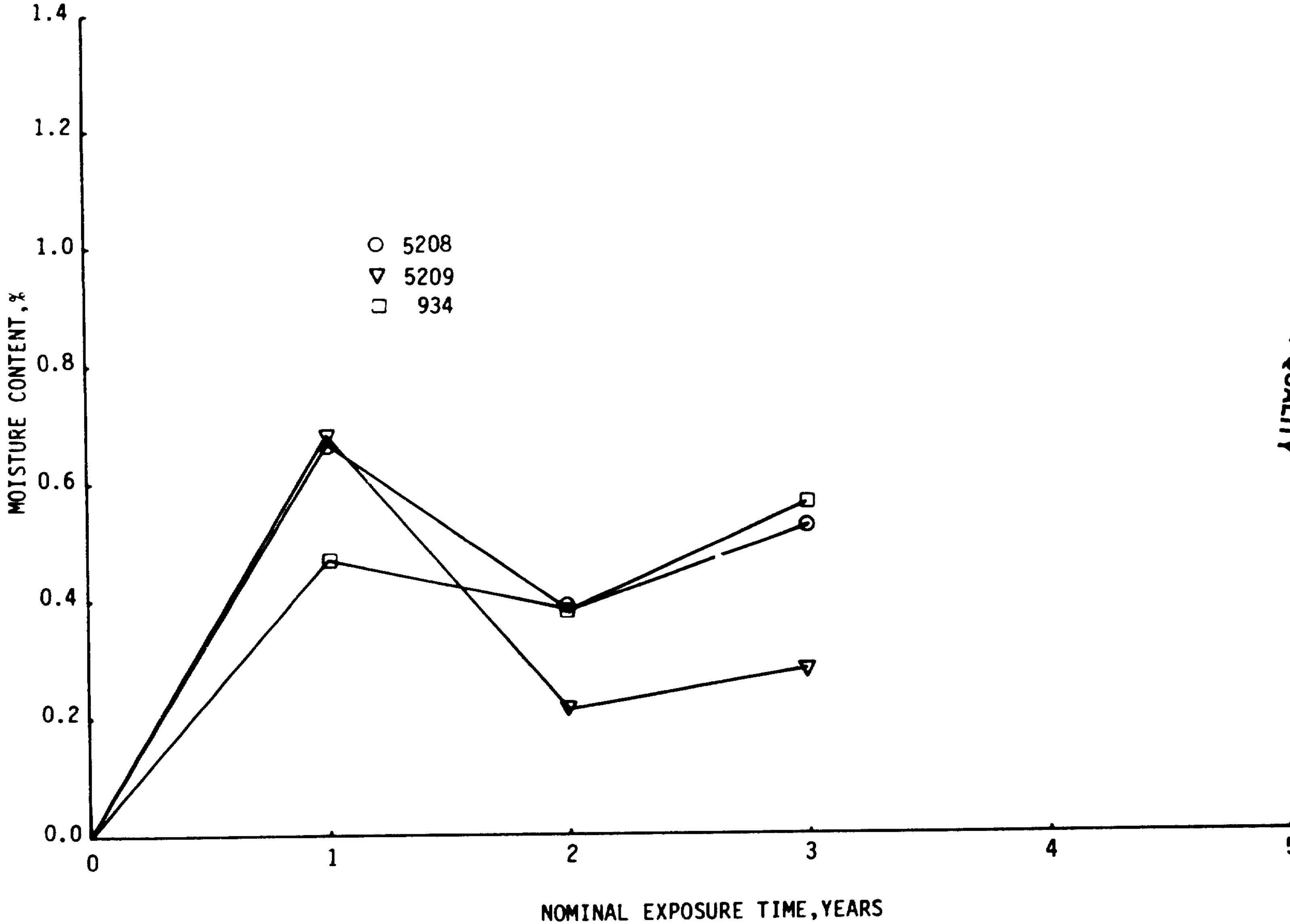


Figure 5-1. Moisture Content Edwards Solar Exposure.

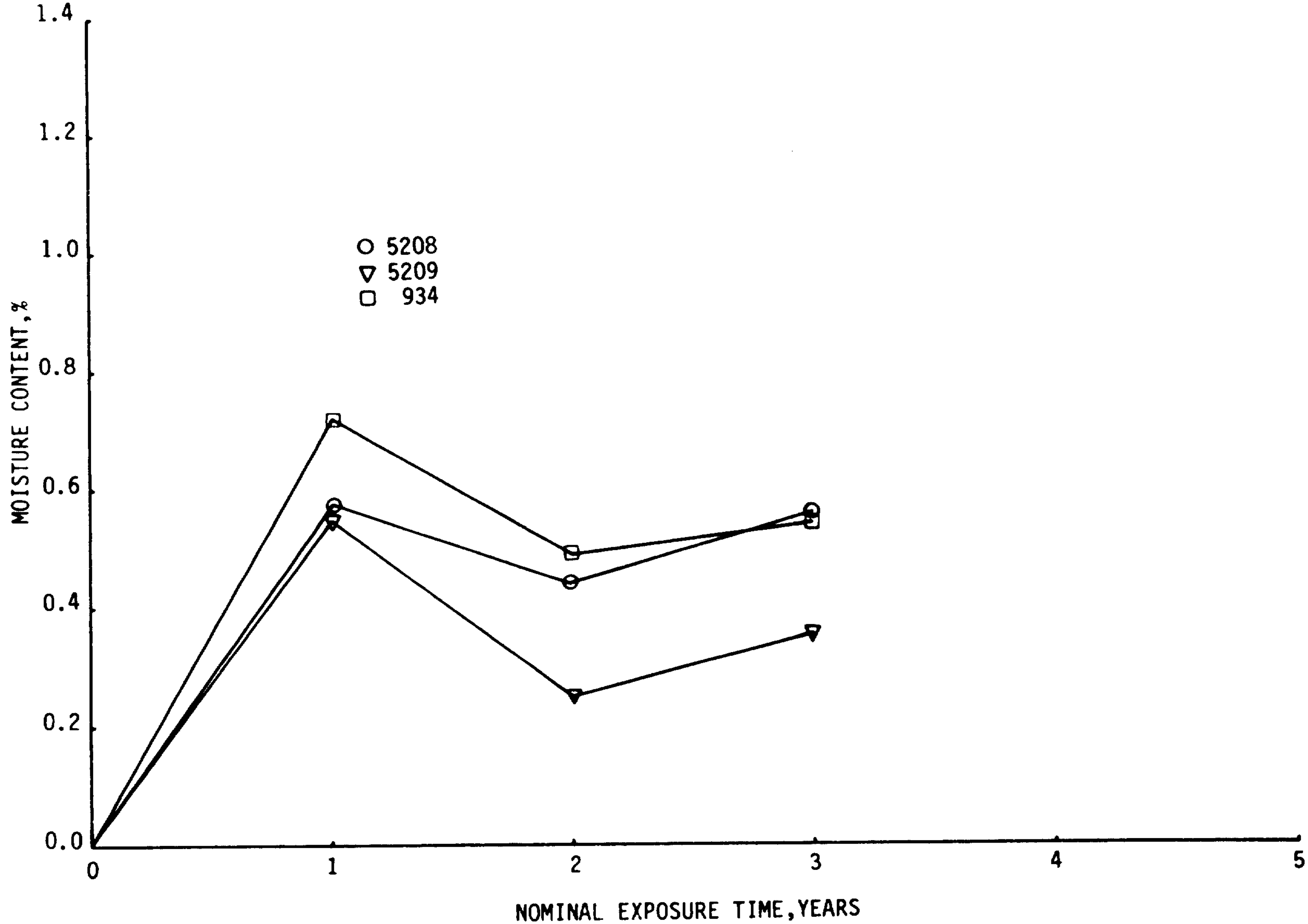


Figure 5-2. Moisture Content Edwards Nonsolar Exposure.

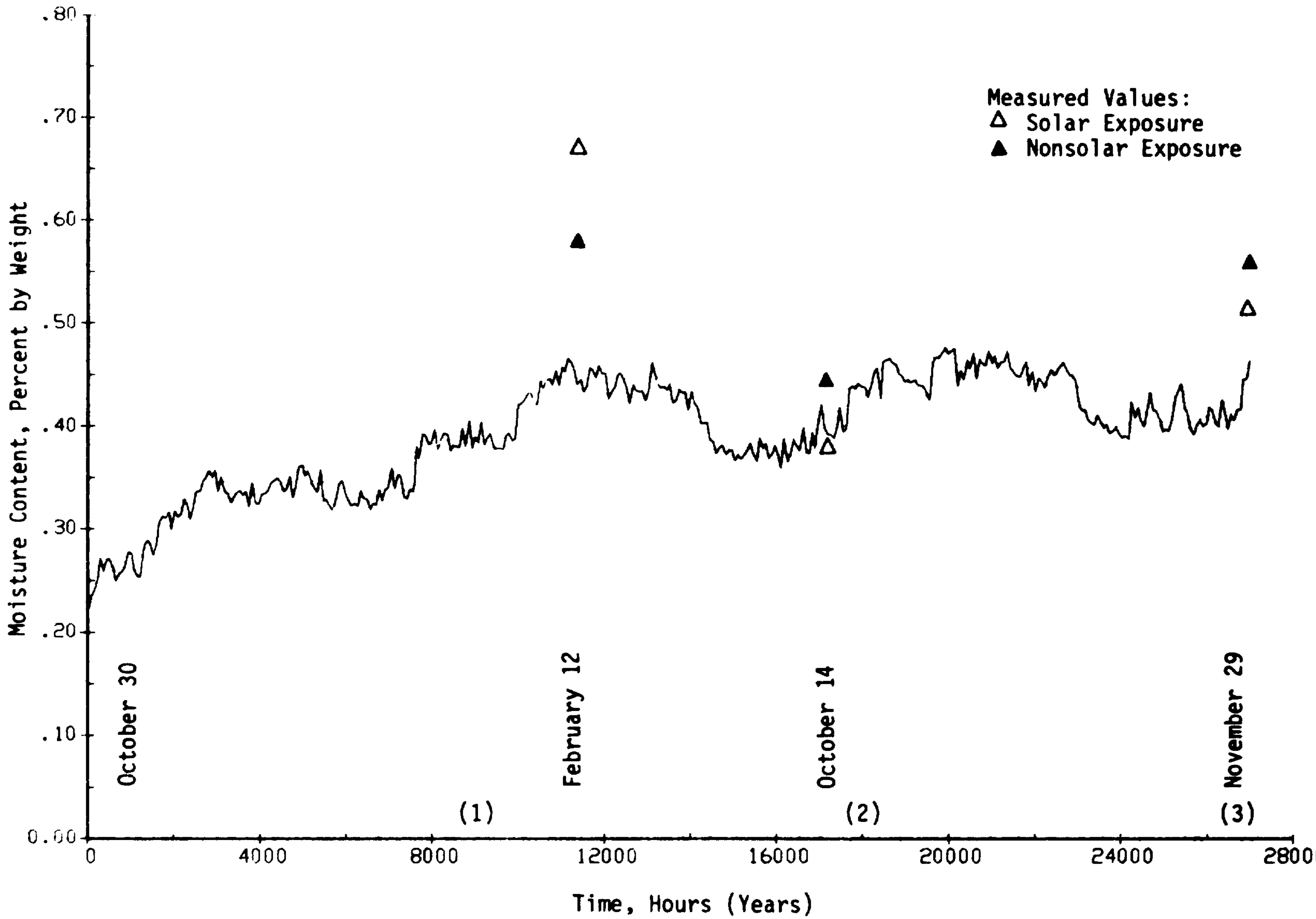
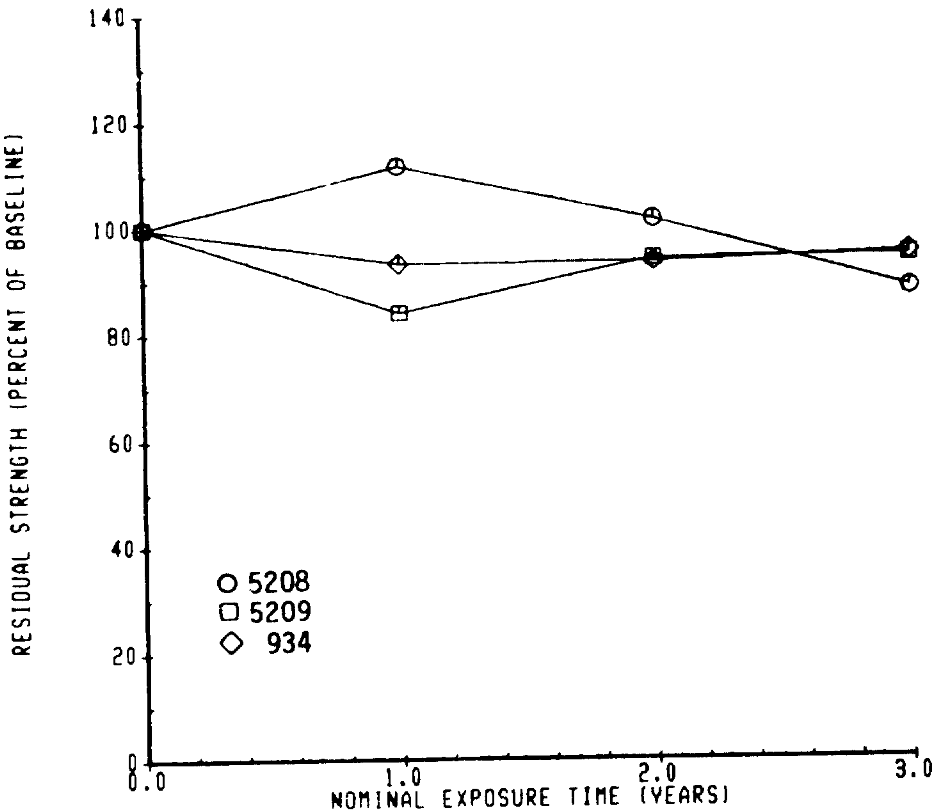
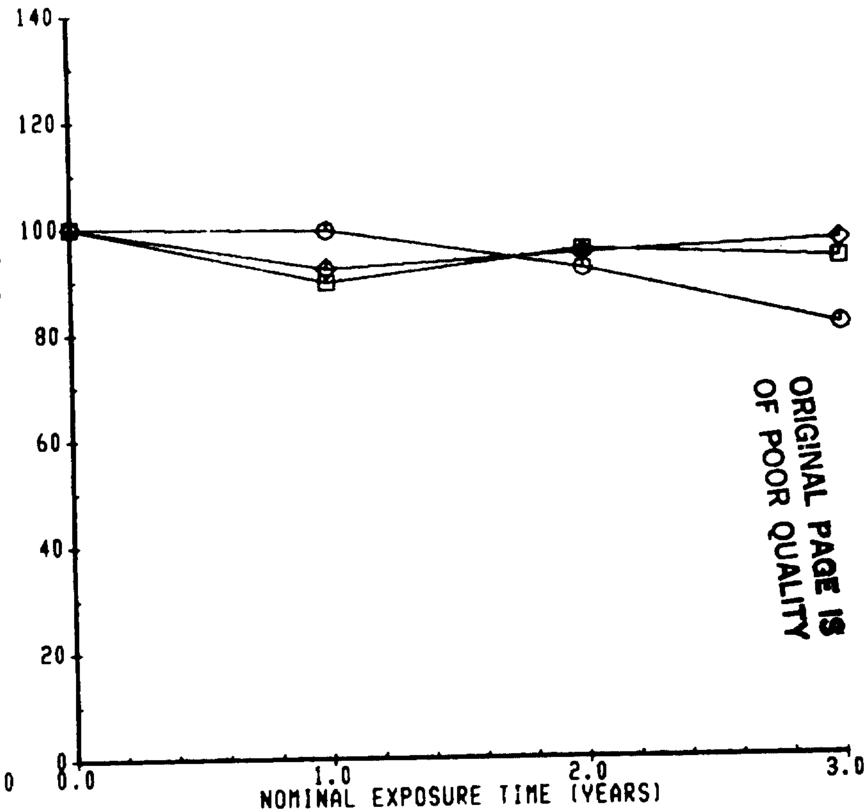


Figure 5-3 Edwards AFB Moisture Content Analysis for T300/5208.

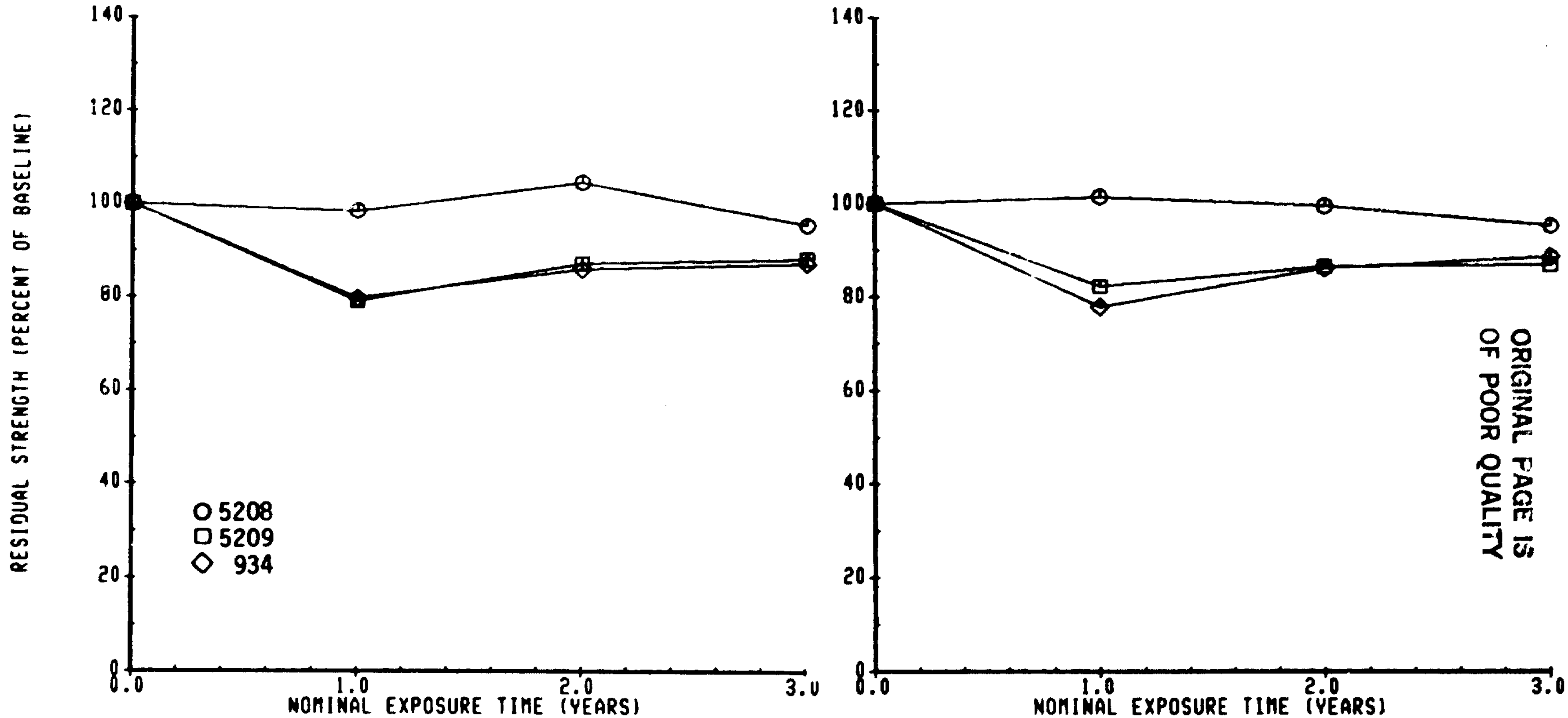


A. Solar Exposure



B. Nonsolar Exposure

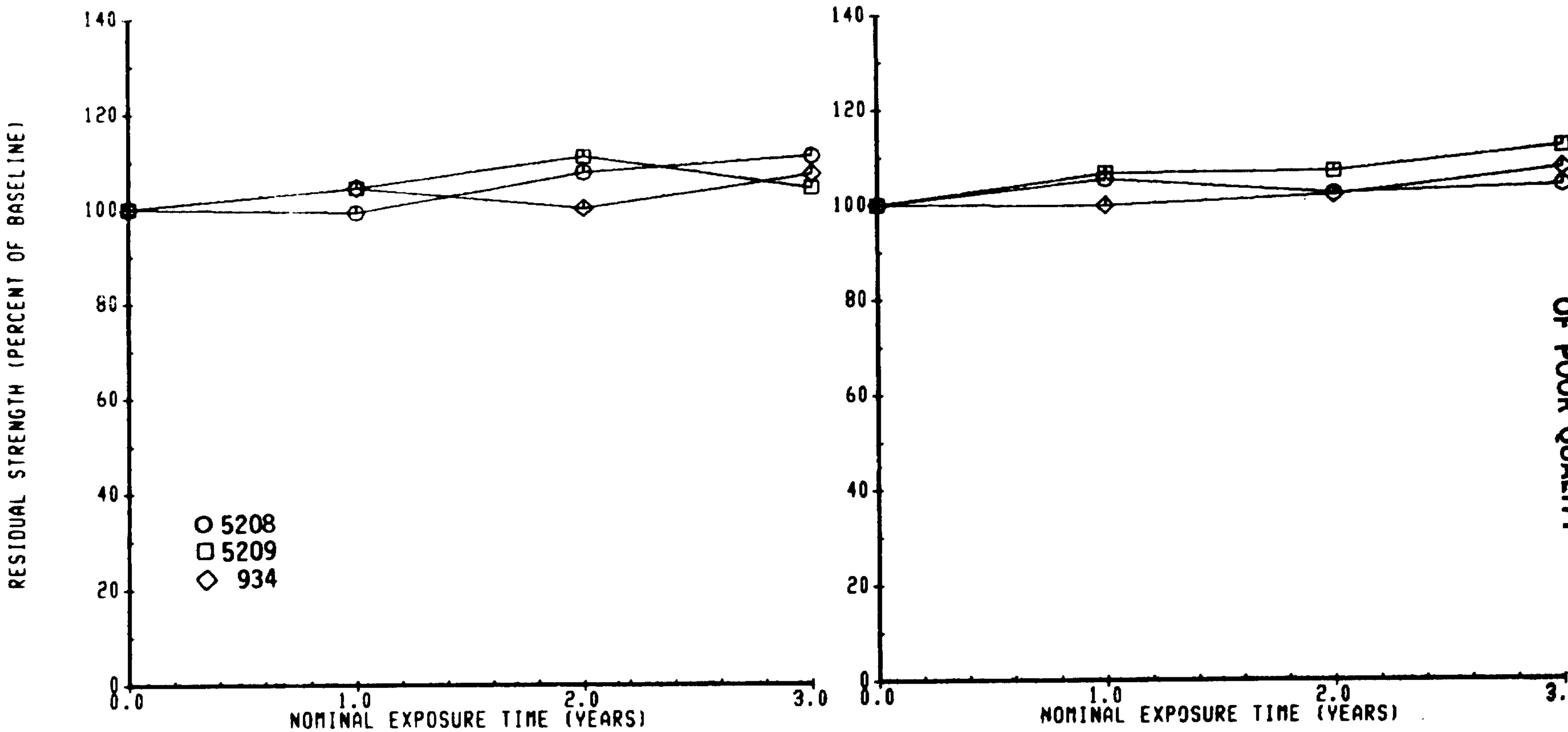
Figure 5-4. Short Beam Shear, Edwards AFB Ground Rack, Tested at Room Temperature.



A. Solar Exposure

B. Nonsolar Exposure

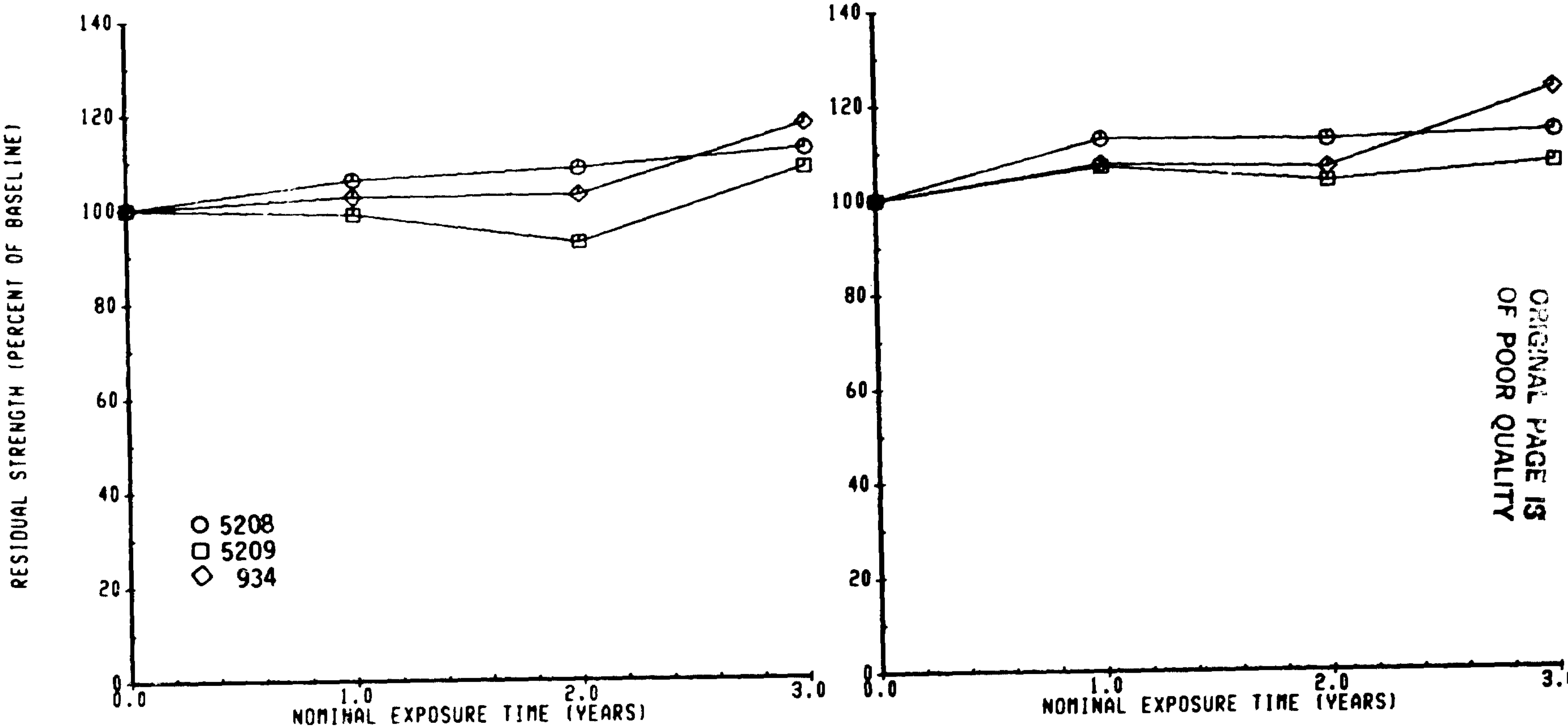
Figure 5-5 . Short Beam Shear, Edwards AFB Ground Rack, Tested at 180°F.



A. Solar Exposure

B. Nonsolar Exposure

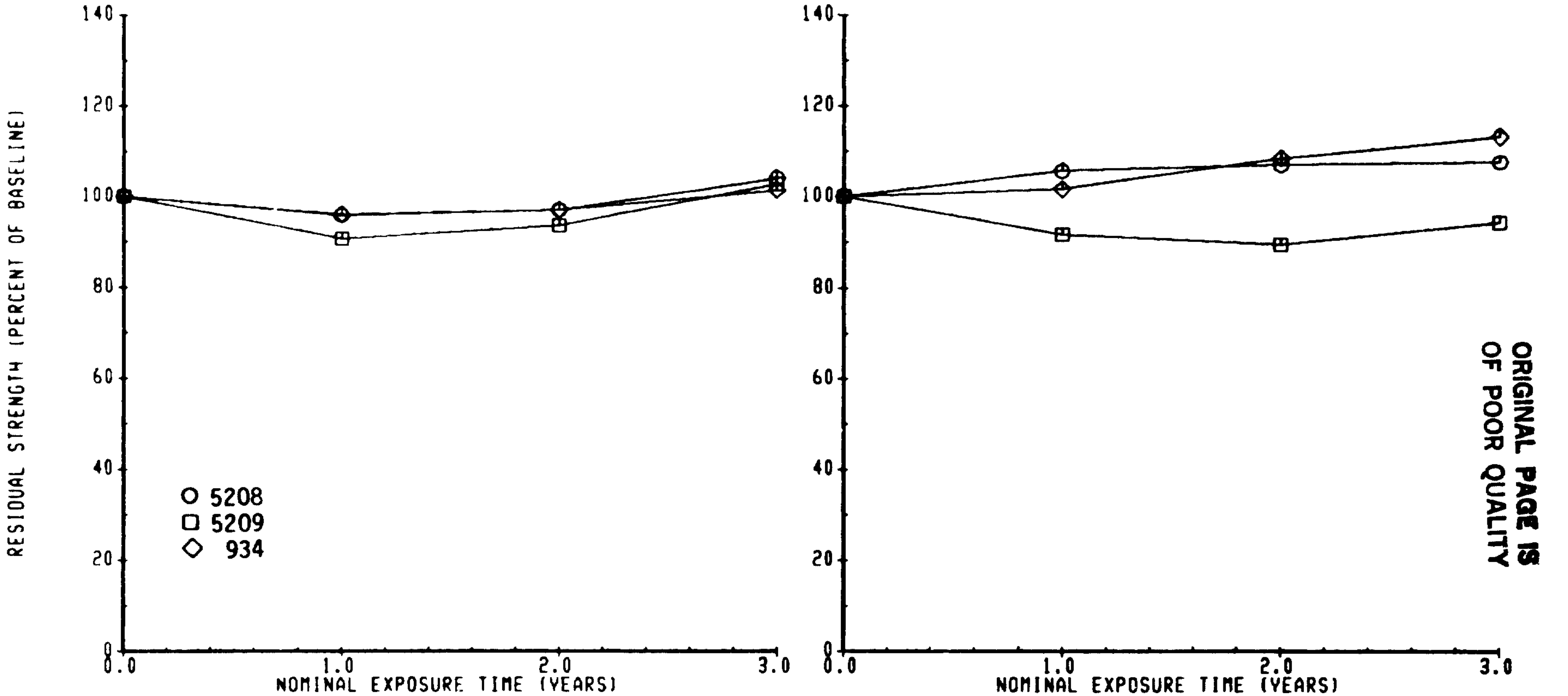
Figure 5-6 . Flexure, Edwards AFB Ground Rack, Tested at Room Temperature.



A. Solar Exposure

B. Nonsolar Exposure

Figure 5-7 . Flexure, Edwards AFB Ground Rack, Tested at 180^{o}F.



A. Unstressed Tension, Solar Exposed

B. Stressed Tension, Nonsolar Exposed

Figure 5-8 . ± 45 Tension, Edwards AFB Ground Rack, Tested at 180^{o}F.

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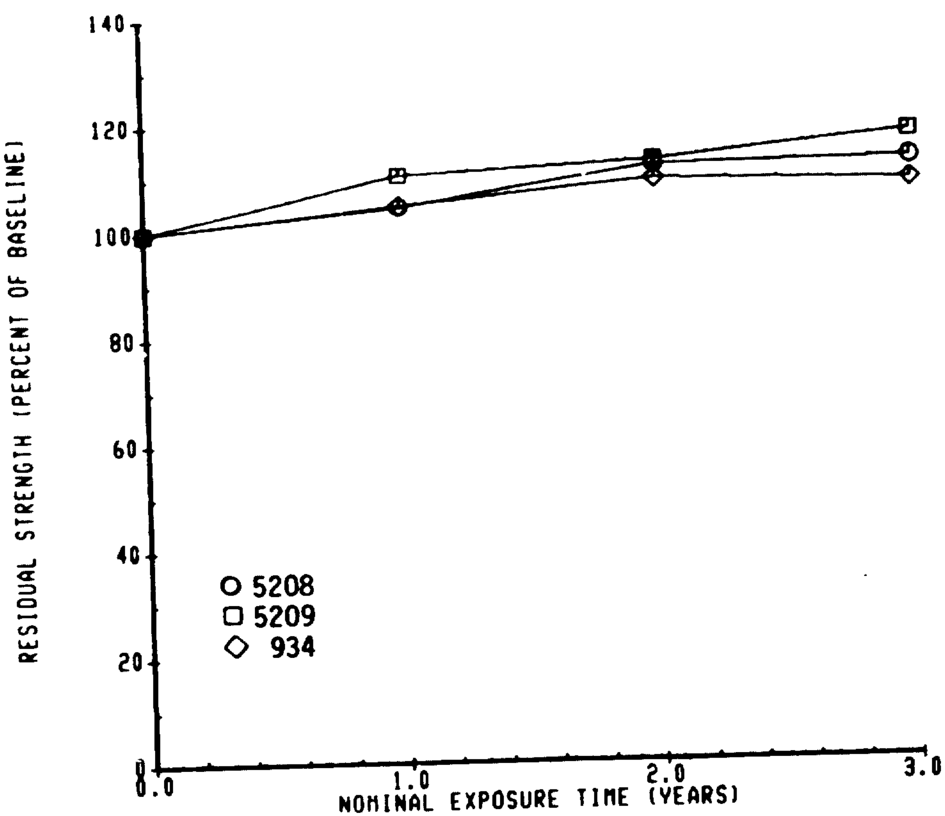
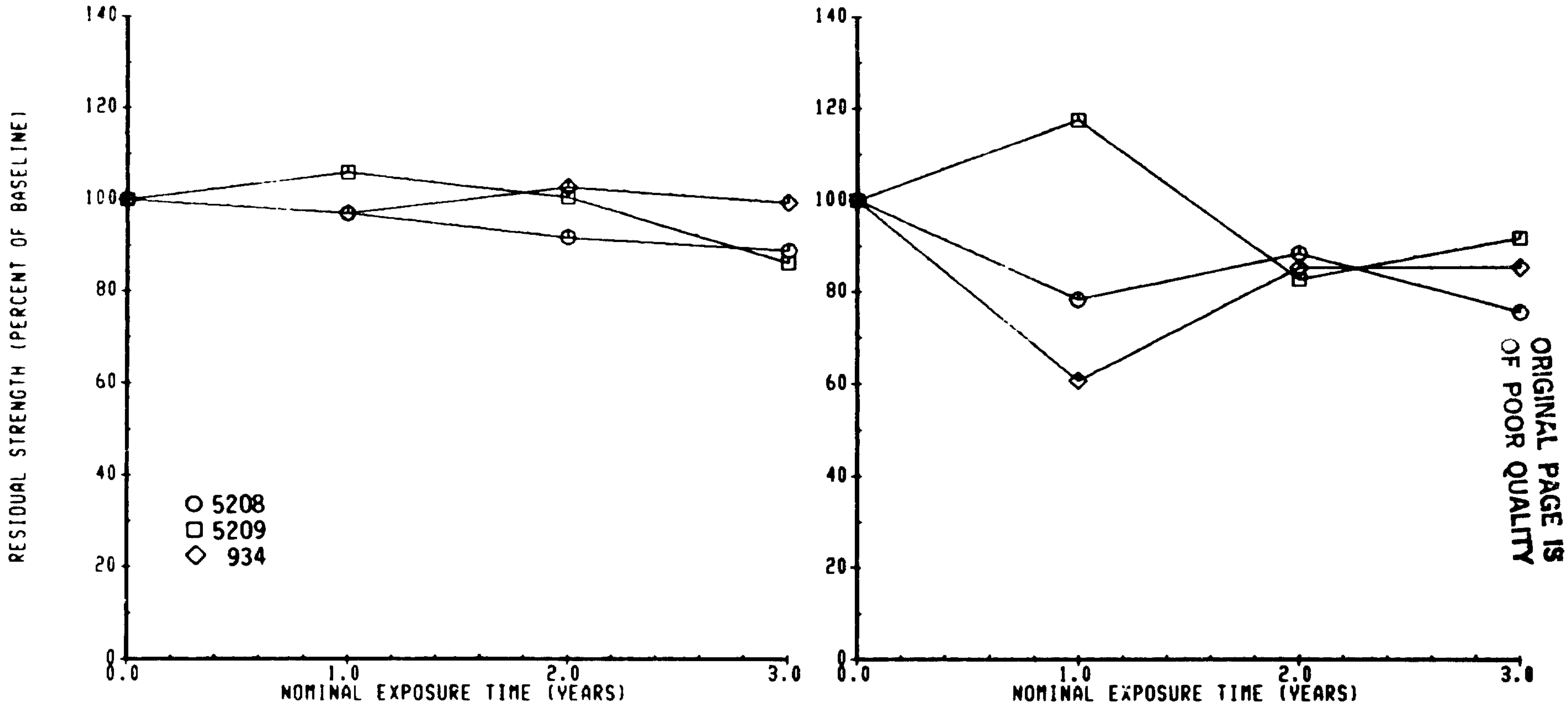


Figure 5-9 . ± 45 Tension, Solar Exposure, Edwards AFB Ground Rack, Tested at Room Temperature.



A. Tested at Room Temperature

B. Tested at 180°F.

Figure 5-10. 0° Compression Strength, Nonsolar Exposure, Edwards AFB Ground Rack.

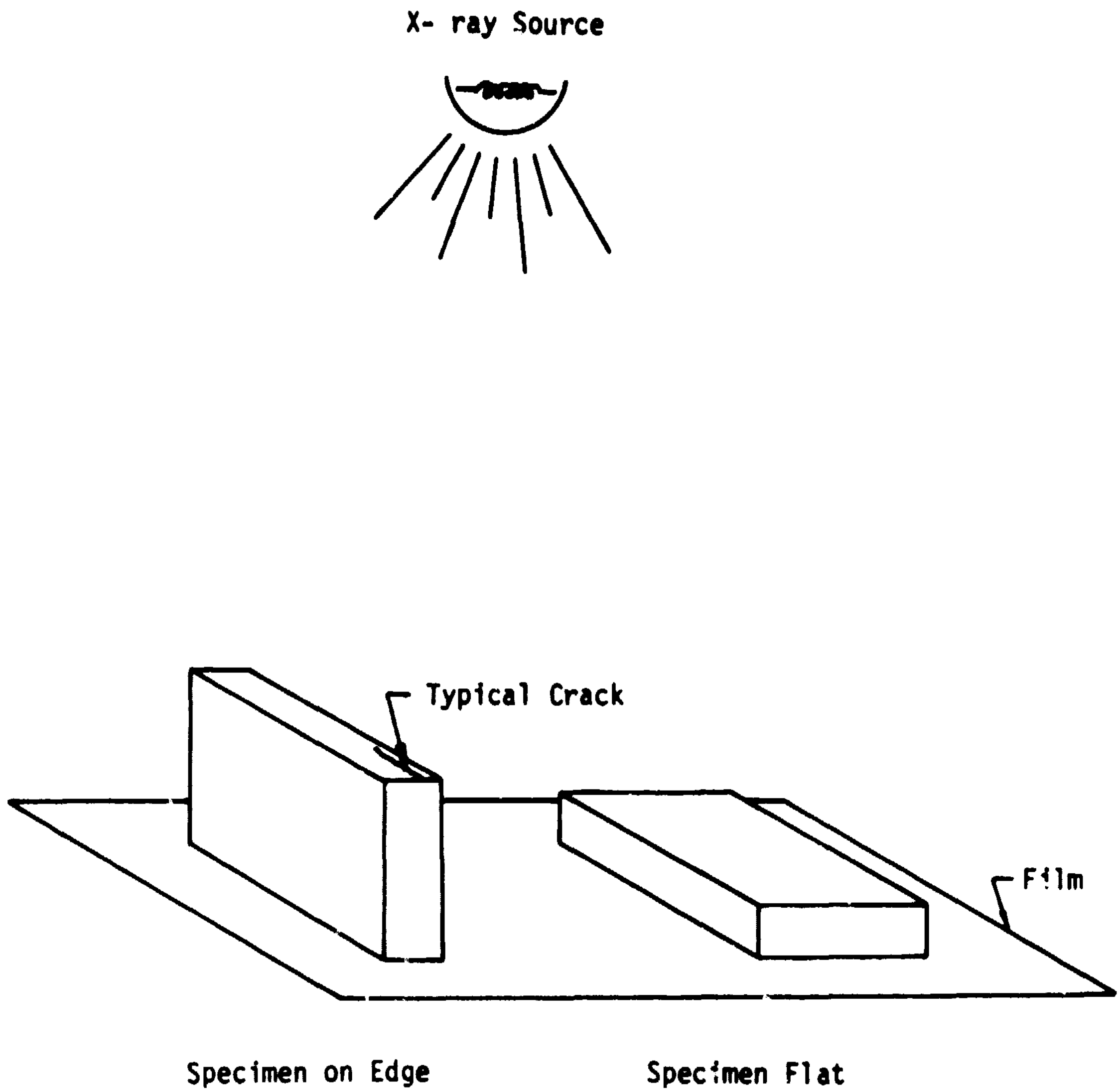
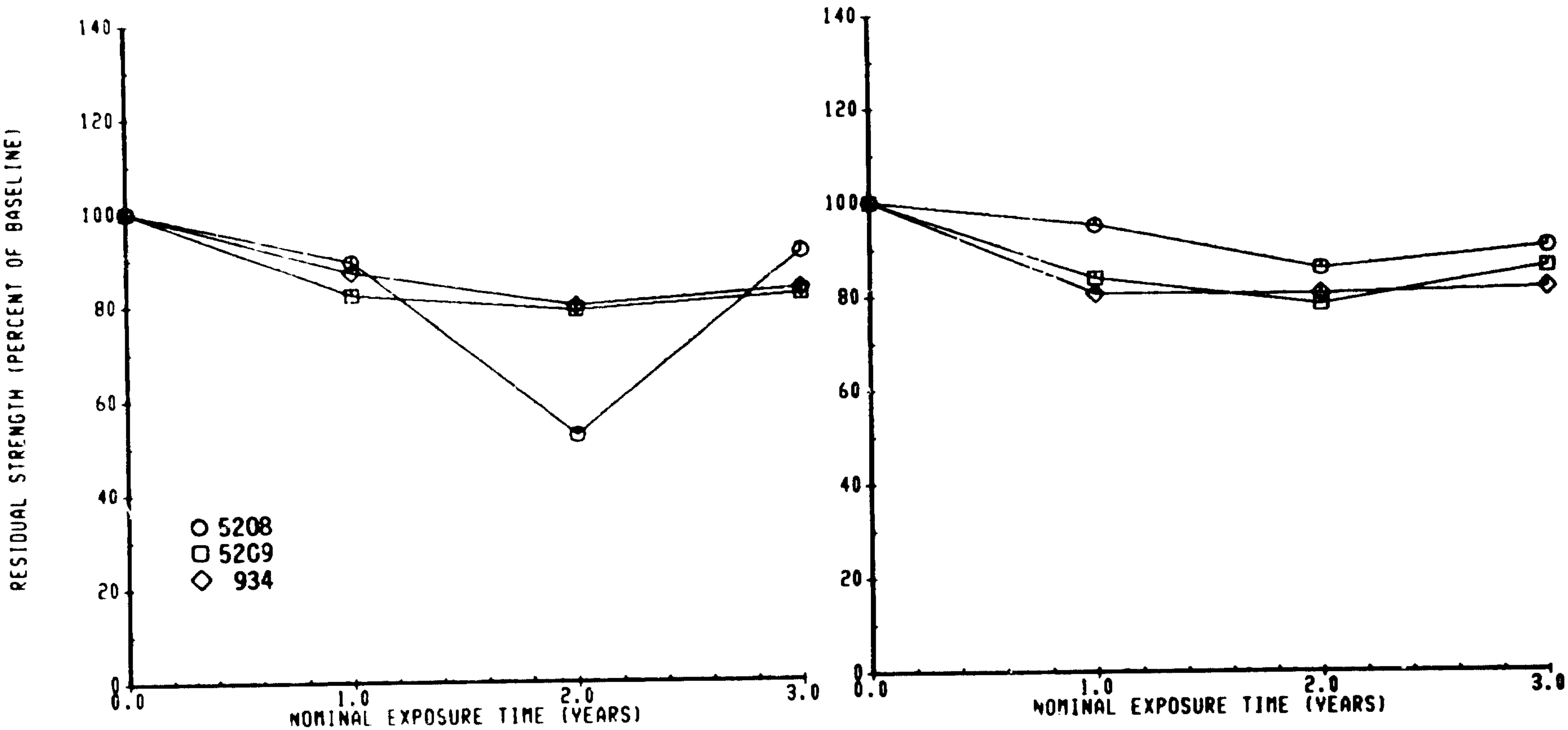


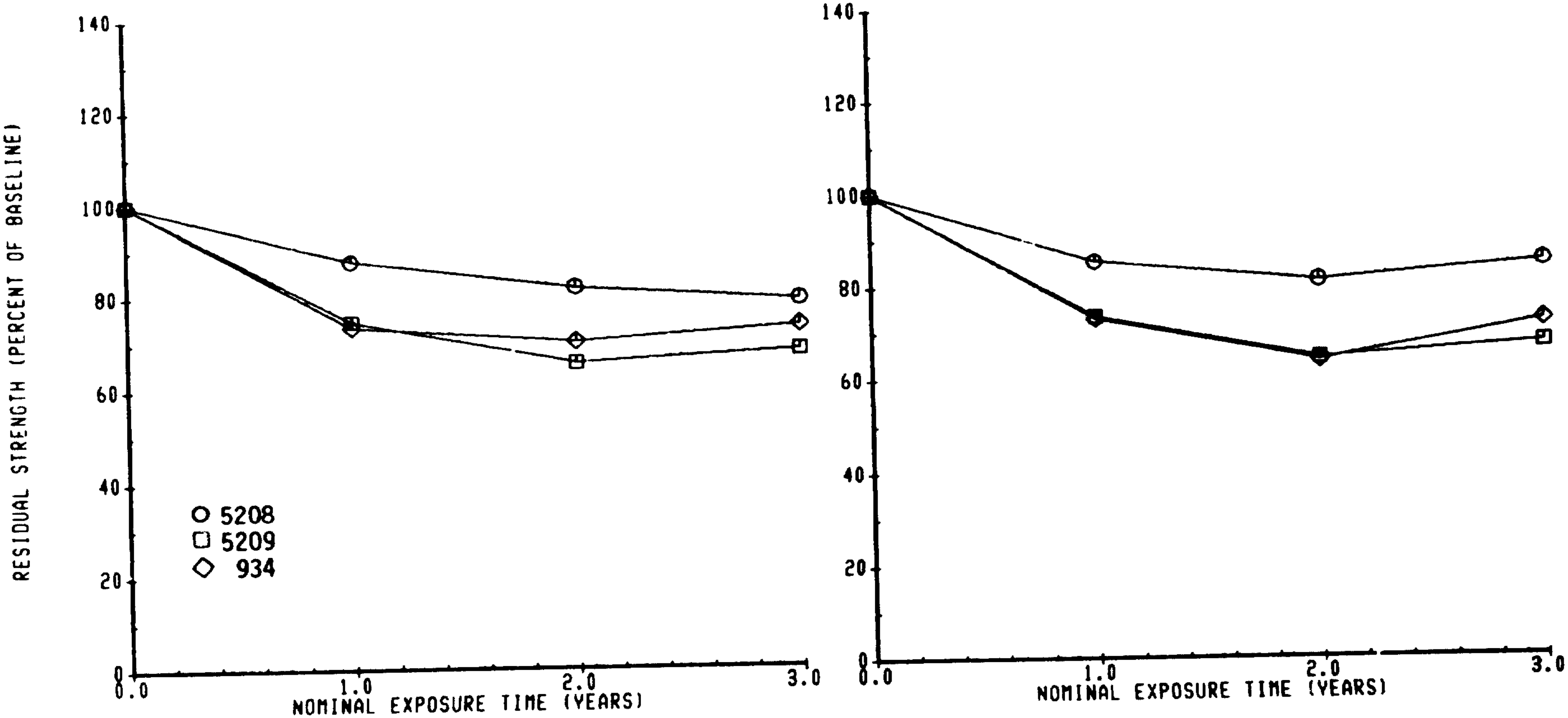
Figure 5-11 . X - ray Radiograph Set up



A. Solar Exposure

B. Nonsolar Exposure

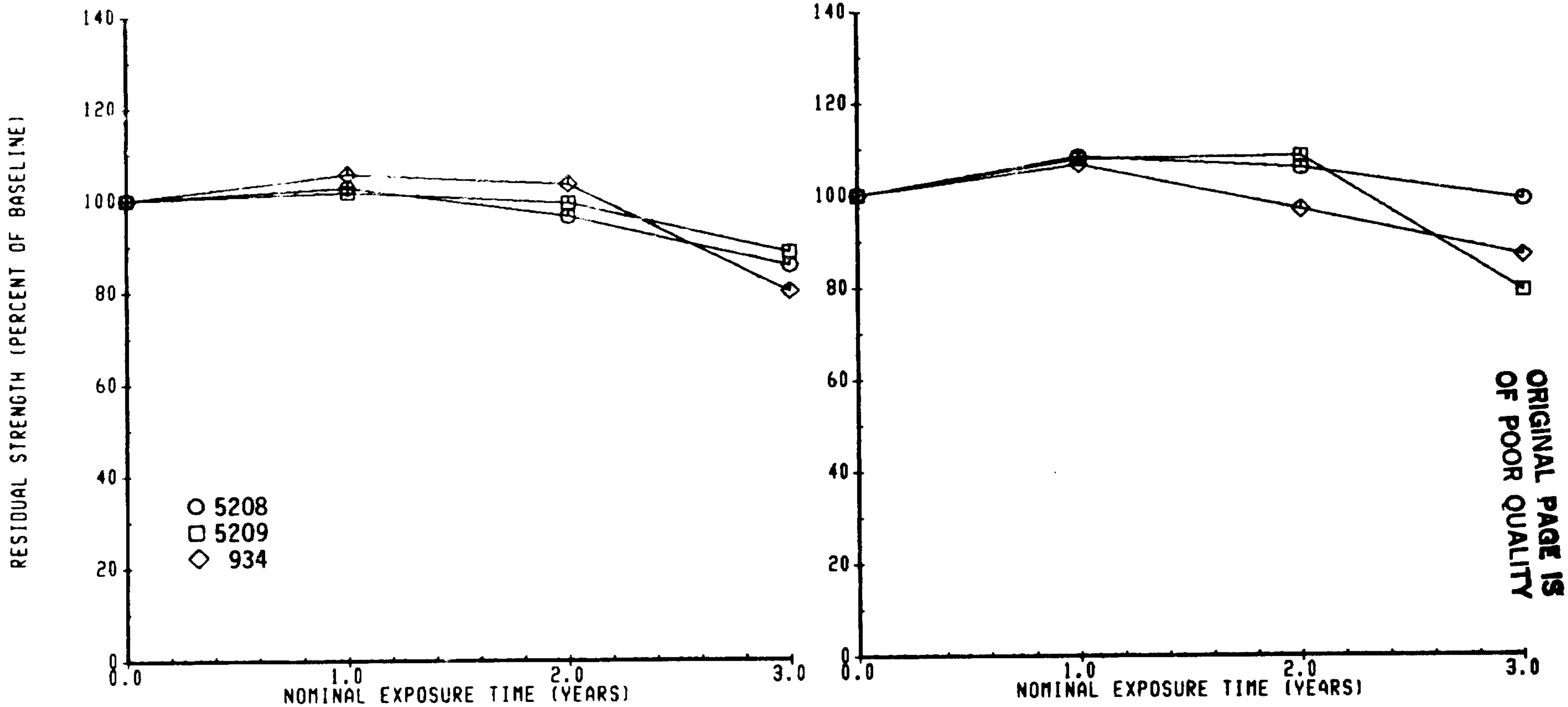
Figure 5-12 . Short Beam Shear, Honolulu Ground Rack, Tested at Room Temprature.



A. Solar Exposure

B. Nonsolar Exposure

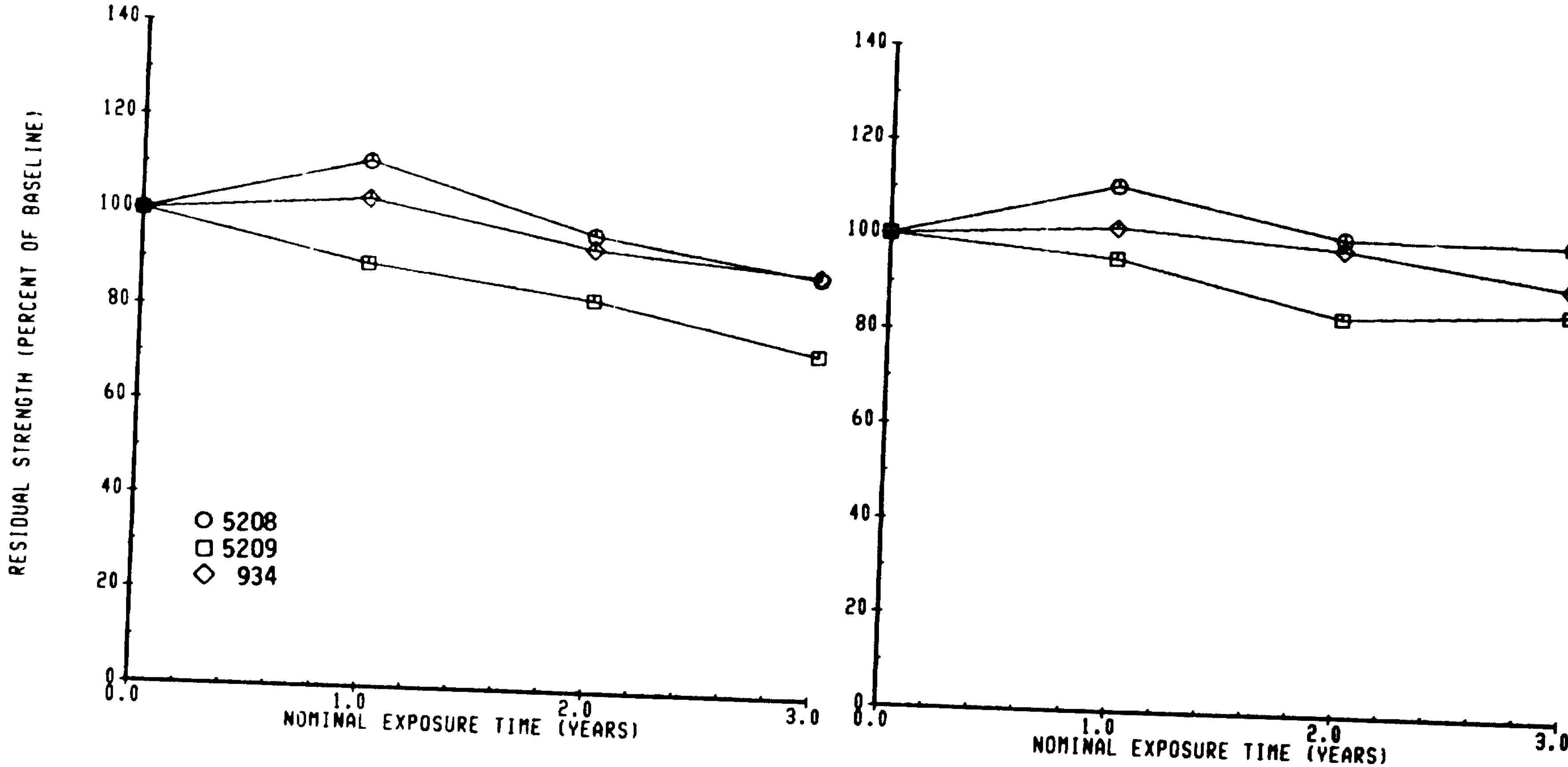
Figure 5-13 . Short Beam Shear, Honolulu Ground Rack, Tested at 180°F.



A. Solar Exposure

B. Nonsolar Exposure

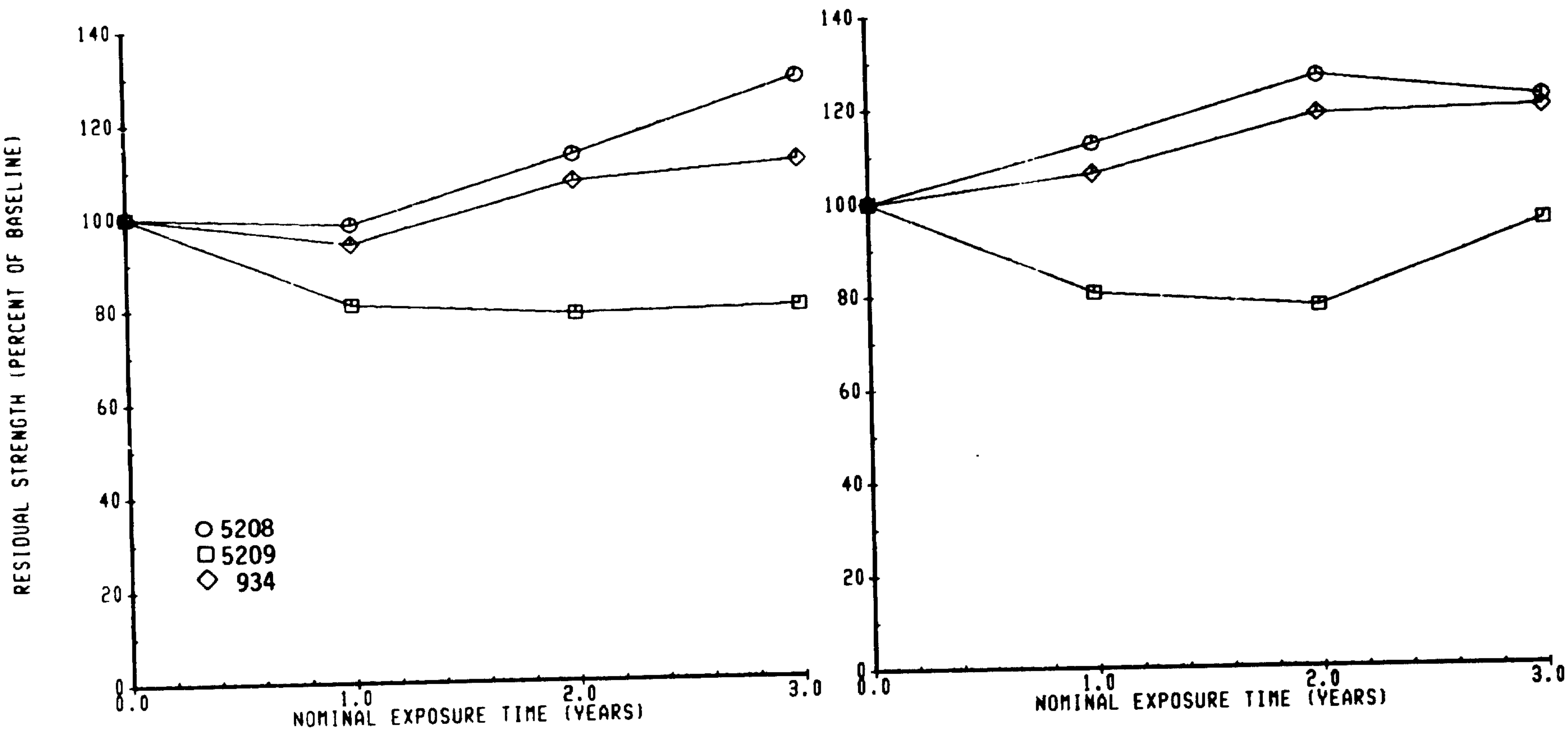
Figure 5-14 . Flexure, Honolulu Ground Rack, Tested at Room Temperature.



A. Solar Exposure

B. Nonsolar Exposure

Figure 5-15 . Flexure, Honolulu Ground Rack, Tested at 180°F.



A. Unstressed Tension, Solar Exposed

B. Stressed Tension, Nonsolar Exposed

Figure 5-16 . ± 45 Tension, Honolulu Ground Rack, Tested at 180°F.

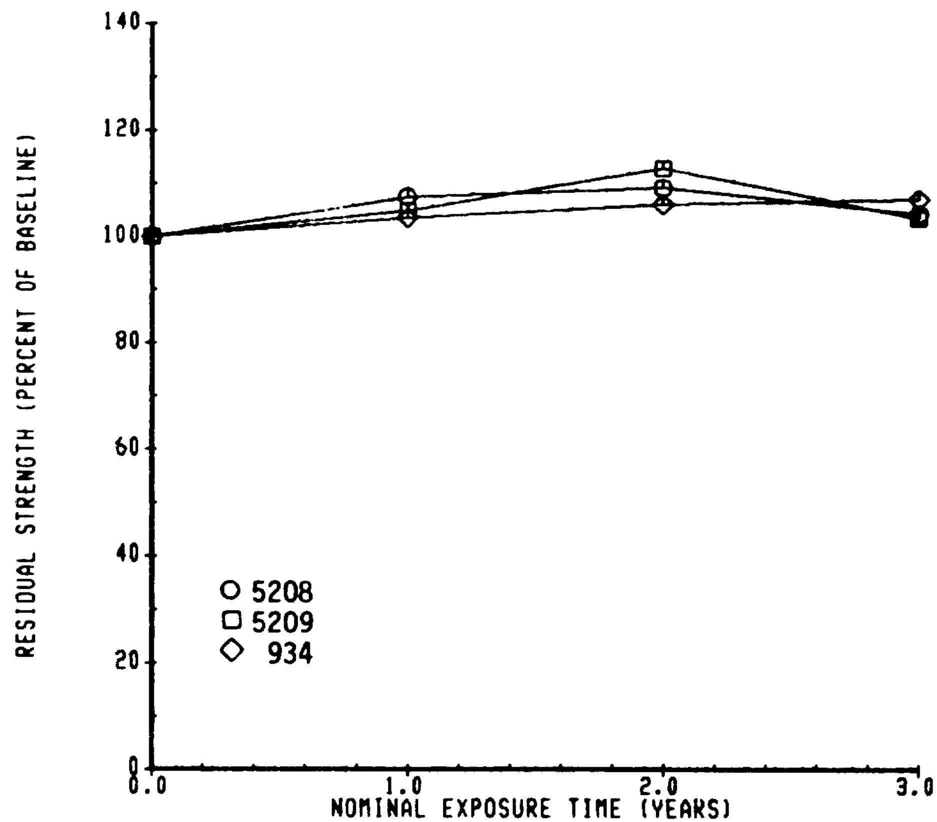
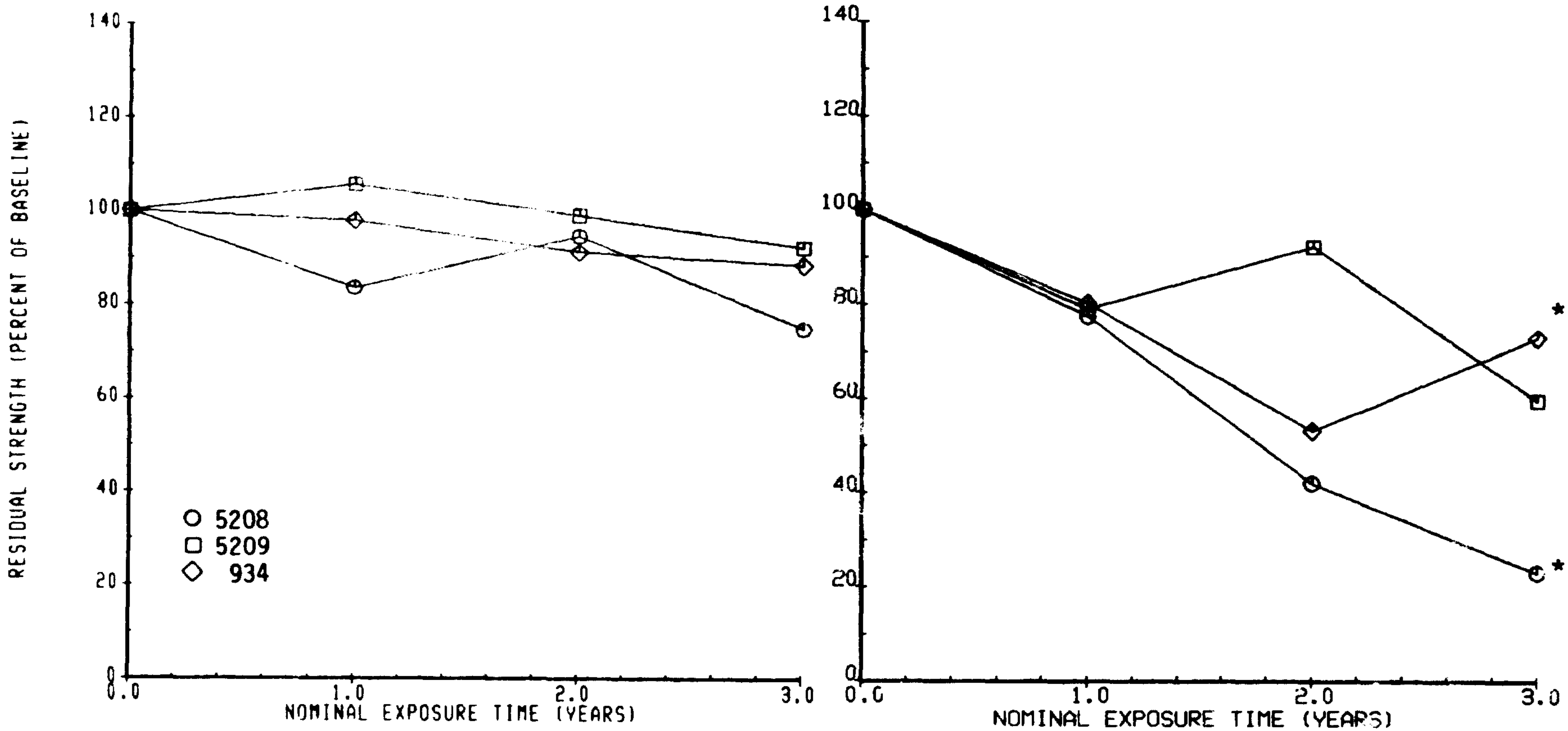


Figure 5-17 . ± 45 Tension, Solar Exposure, Honolulu Ground Rack, Tested at Room Temperature.

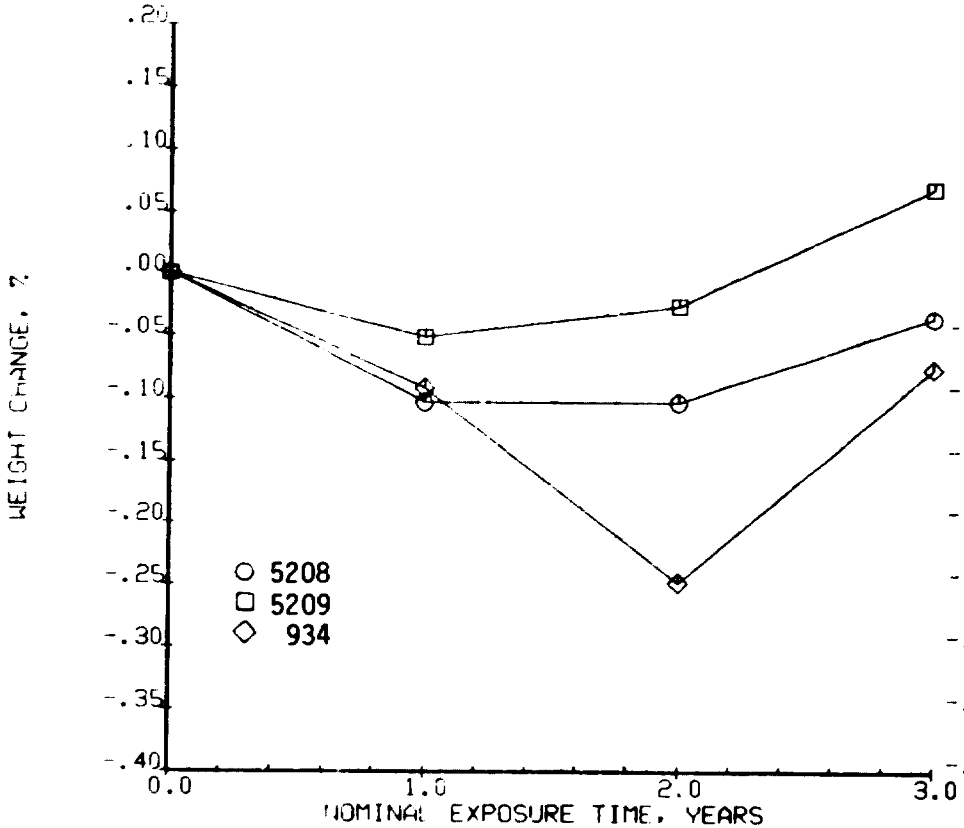


A. Tested at Room Temperature

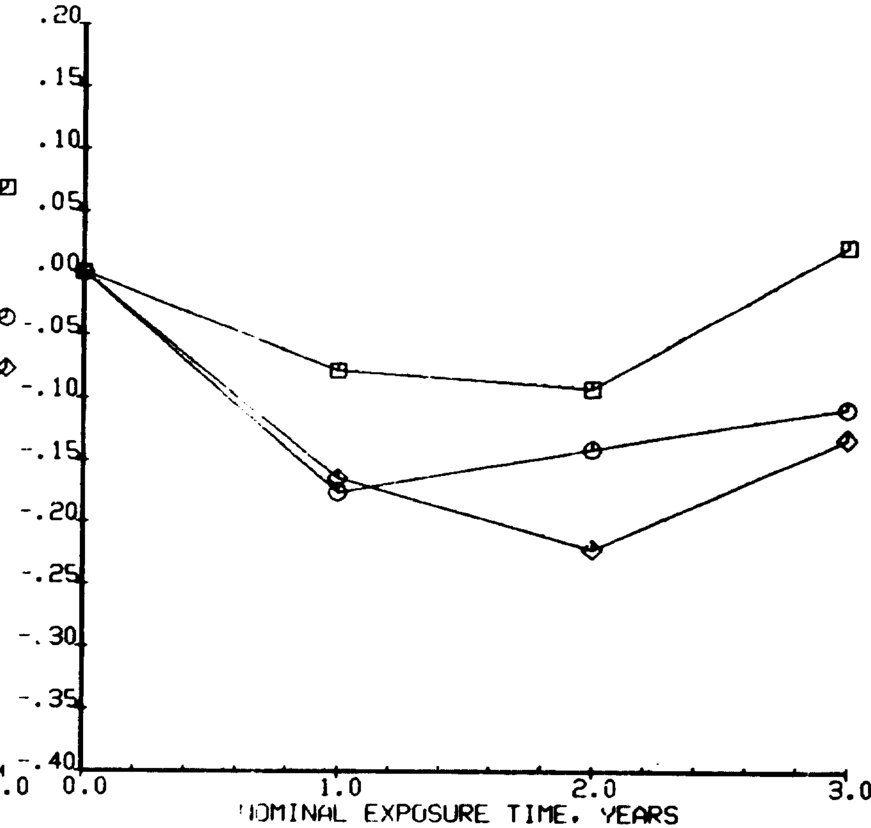
B. Tested at 180^{o}F.

* See Notes Table 5-6

Figure 5-18 . 0^{o} Compression Strength, Nonsolar Exposure, Honolulu Ground Rack.

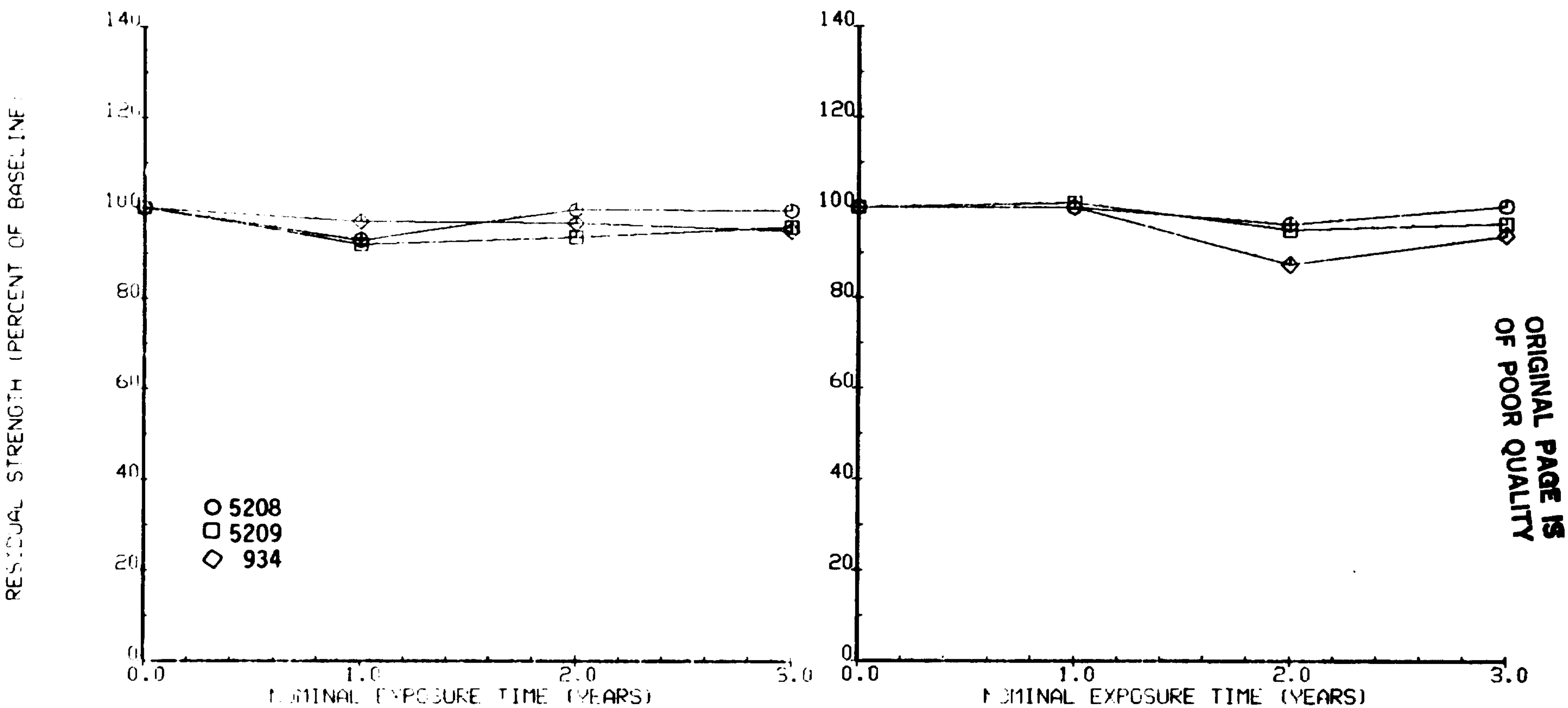


A. Short Beam Shear Configuration



B. Flexure Configuration

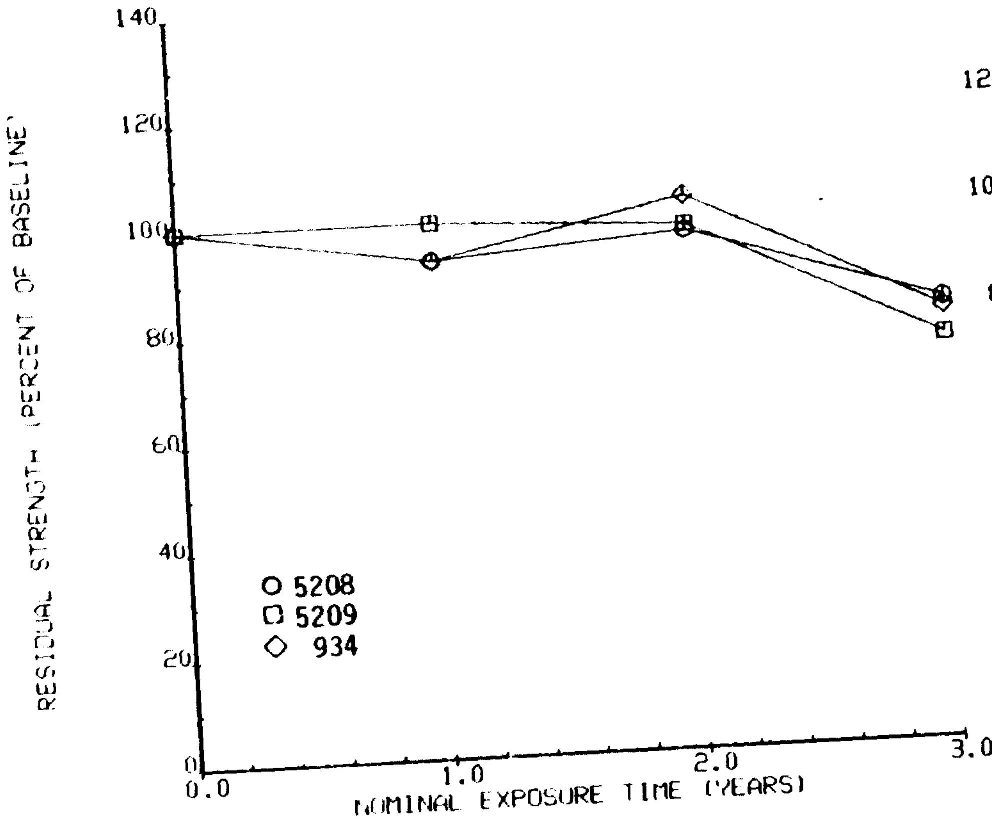
Figure 5-19. Time Alone Weight Change Results.



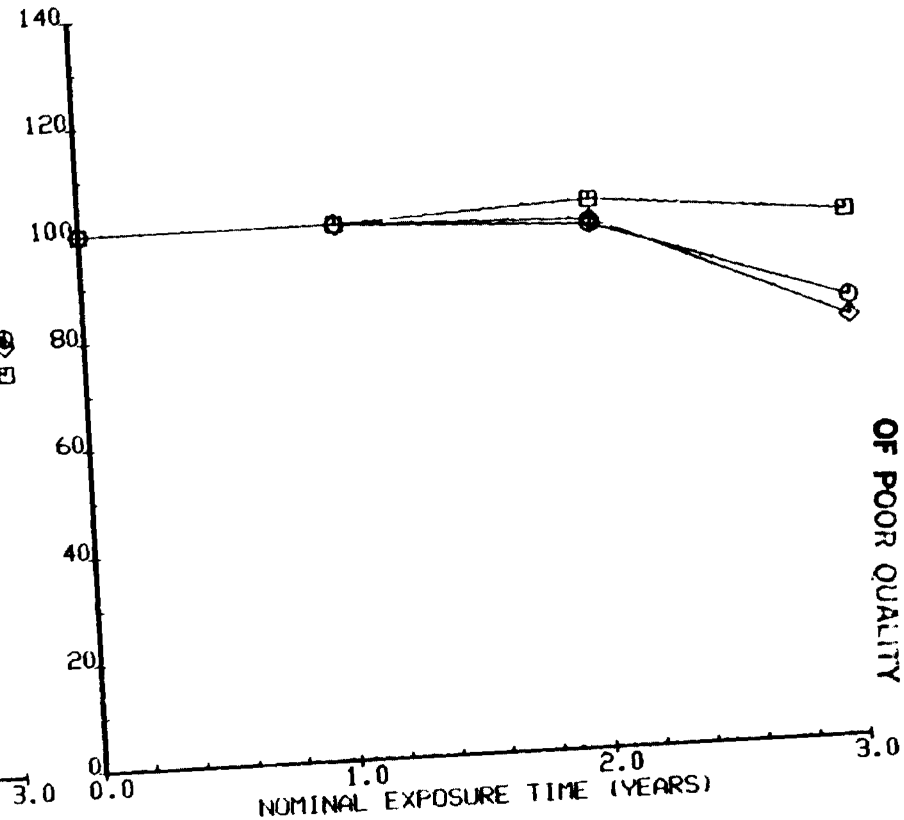
A. Room Temperature Test

B. 180°F Test

Figure 5-20 . Time Alone Short Beam Shear Strength.



A. Room Temperature Test



B. 180^{0}F Test

Figure 5-21 . Time Alone Flexure Strength.

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Table 5-1. Long Term Airplane Exposure Data: Task I

T300/5208, T300/5209, T300/934	INSTALLATION DATE	EXPOSURE AS OF MARCH 31, 1982		
		EXPOSURE TIME, DAYS	FLIGHT HOURS	FLIGHT CYCLES
Aloha Airlines				
- 3 Years	3-14-80	747	3427	9268
- 7 Years	2-14-81	369	1694	4470
- 10 Years	2-16-79[1]	1139	4459	12099
Air New Zealand				
- 3 Years	3-23-81	373	2144	2987
- 7 Years	10-20-81	162	917	1324
- 10 Years	7-2-79[1]	968	4824	6647
Southwest Airlines				
- 3 Years	6-21-81	283	2709	3570
- 2 Years	2-27-80	763	7330	9758
- 10 Years	6-22-80	647	6167	8242
AS1/3501-6				
Aloha Airlines				
1, 2, 10 Years	9-29-81	183	692	1829
Air New Zealand				
1, 2, 10 Years	10-22-81	160	880	1341
Southwest Airlines				
1, 2, 10 Years	3-31-82	-	-	-
Kevlar 49/F161-188				
Aloha Airlines				
1, 2, 10 Years	10-9-81	173	638	1662
Air New Zealand				
1, 2, 10 Years	10-23-81	159	863	1242
Southwest Airlines				
1, 2, 10 Years	-	-	-	-

[1] Specimens transferred to another 737 airplane after initial deployment.

Table 5-2. Long Term Ground Based Exposure Data: Task II

LOCATION	T300/5208, T300/5209, T300/934		AS1/3501-6 KEVLAR 49/F161-188	
	Installation Date	Exposure Time, Days	Installation Date	Exposure Time Days
Edwards AFB	12-6-78[1]	1151	12-16-81	105
Honolulu, Hawaii	2-9-79	1085	9-29-81	153
Wellington, New Zealand	7-4-79	941	10-29-81	123
Dallas, Texas	4-18-80	712	12-3-81	118

[1]Rack stored in unheated warehouse at Dryden Flight Research Center from 10-30-78 to installation date.

Table 5-3 Results Summary, Edwards, Nominal 3 Year Solar Specimens*

PROPERTY	SPECIMEN CONFIGURATION	MATERIAL SYSTEM		
		5208	5209	934
Room Temperature Residual Strength Data (% of Baseline)**	SBS Flexure ±45 Tension	88.2 111.1 112.4	94.4 104.3 117.2	94.9 107.3 108.2
Elevated Temperature Residual Strength Data (% of Baseline)**	SBS Flexure ±45 Tension SBS Dryout	95.5 112.1 103.9	88.3 108.0 102.7	87.29 117.5 101.4
Weight Change Data Percent Gain + Percent Loss -	SBS Flexure + 45 Tension	0.0432 -0.1760 -0.2617	0.0153 -0.2823 -0.1841	0.0540 -0.2075 -0.1806
Weight Change During Dryout		0.52	0.27	0.56

Notes:

* These specimens exposed for 1121 days.

** Residual strength data based on baseline tests at the respective temperatures.

Table 5-4. Results Summary, Edwards, Nominal 3 Year Non-Solar Specimens*

PROPERTY	SPECIMEN CONFIGURATION	MATERIAL SYSTEM 5208	5209	934
Room Temperature Residual Strength Data (% of Baseline)**	SBS Flexure 0° Compression	80.9 103.9 88.8	93.1 112.0 86.1	96.5 107.5 99.3
Elevated Temperature Residual Strength Data (% of Baseline)**	SBS Flexure 0° Compression Stressed Tension SBS Dryout	95.0 113.7 75.5 + 107.4	86.8 107.1 91.7 94.2	88.4 122.6 85.2 113.0
Weight Change Data Percent Gain + Percent Loss -	SBS Flexure Stressed Tension	0.0679 -0.0987 0.0420	-0.2247 -0.2586 -0.0763	0.1243 -0.1832 -0.0070
Weight Change During Dryout		0.56	0.35	0.54

\+ Gripping Tab Failure

Notes:

* These specimens exposed for 1121 days.

** Residual strength data base on baseline tests at the respective temperatures.

Table 5-5. Results Summary, Honolulu Nominal 3 Year Solar Exposure*

PROPERTY	SPECIMEN CONFIGURATION	MATERIAL SYSTEM		
		5208	5209	934
Room Temperature Residual Strength Data (% of Baseline)**	SBS Flexure ±45 Tension	91.0 85.6 104.1	82.2 88.4 103.4	83.3 80.0 106.8
Elevated Temperature Residual Strength data (% of Baseline)**	SBS Flexure ±45 Tension	78.8 88.0 128.4	68.0 72.5 79.5	73.2 89.2 110.6
Weight Change Data Percent Gain + Percent Loss -	SBS Flexure ±45 Tension	.5035 .2172 -.2628	.2863 .0324 -.3496	.5019 .2426 -.2228

Notes:

* These specimens exposed for 1096 days.

** Residual strength data based on baseline tests at the respective temperatures.

Table 5-6. Results Summary, Honolulu Nominal 3 Year Non Solar Exposure*

PROPERTY	SPECIMEN CONFIGURATION	MATERIAL SYSTEM		
		5208	5209	934
Room Temperature Residual Strength Data (% of Baseline)**	SBS Flexure 0^o Compression	90.1 98.8 74.8	85.9 79.2 92.2	81.3 86.7 88.4
Elevated Temperature Residual Strength Data (% of Baseline)**	SBS Flexure 0^o Compression Stressed Tension	84.6 100.5 22.9++ 121.5	67.0 86.0 59.5 95.3	71.9 91.5 72.8+ 119.2
Weight Change Data Percent Gain + Percent Loss -	SBS Flexure Stressed Tension	.5507 .3907 .6205	.4082 .2114 .3230	.6340 .3928 .5898

\+ Value represents one specimen test. Gripping tab slippage on other two specimens.
++ Gripping tab slippage

Notes:

* These specimens exposed for ~~740~~ 1096 days.

** Residual strength data based on baseline tests at the respective temperatures.

Table 5-7. Cracked Short Beam Shear Specimen Strength Summary Honolulu 3-Year Exposure

	Material	Exposure	Test Temp	Uncracked Specimen Strength % of Baseline	Cracked Specimen Strength % of Baseline	Average Number of Cracks
1	5208	Solar	180°F	75.1	86.2	5[1]
2	5209	NonSolar	180°F	68.1	64.9	1
3	5209	Solar	R.T.	82.7	81.2	2
4	5209	Solar	180°F	68.0	68.0	2
5	934	NonSolar	R.T.	82.0	79.8	1
6	934	NonSolar	180°F	69.9	73.0	1[2]
7	934	Solar	R.T.	82.0	85.9	1

1 One crack extends slightly more than .1" in from end.

2 Cracks extend about .2" in from end.

Table 5-8. Results Summary, 3 Year Time Alone

PROPERTY	SPECIMEN CONFIGURATION	MATERIAL SYSTEM		
		5208	5209	934
Room Temperature Residual Strength Data (% of Baseline)**	SBS Flexure	99.4 82.0	95.8 75.2	95.0 80.4
Elevated Temperature Residual Strength data (% of Baseline)**	SBS Flexure	100.2 82.1	96.2 98.1	93.8 78.5
Weight Change Data Percent Gain + Percent Loss -	SBS Flexure	-.0357 -.1080	.0693 .0215	-.0756 -.1325

Notes:

* These specimens exposed for 1150 days.

** Residual strength data based on baseline tests at the respective temperatures.

6.0 REFERENCES

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2. "Environmental Exposure Effects on Composite Materials for Commercial Aircraft", NAS1-15148, Second Quarterly Progress Report, NASA CR-165642.

3. "Environmental Exposure Effects on Composite Materials for Commercial Aircraft", NAS1-15148, Third Quarterly Progress Report, NASA CR-165643.

4. "Environmental Exposure Effects on Composite Materials for Commercial Aircraft", NAS1-15148, Fourth Quarterly Progress Report, NASA CR-165644.

5. "Environmental Exposure Effects on Composite Materials for Commercial Aircraft", NAS1-15148, Fifth Quarterly Progress Report, NASA CR-165645.

6. "Environmental Exposure Effects on Composite Materials for Commercial Aircraft", NAS1-15148, Sixth Quarterly Progress Report, NASA CR-165646.

7. "Environmental Exposure Effects on Composite Materials for Commercial Aircraft", NAS1-15148, Seventh Quarterly Progress Report, NASA CR-165647.

8. "Environmental Exposure Effects on Composite Materials for Commercial Aircraft", NAS1-15148, Eighth Quarterly Progress Report, NASA CR-165648.

9. "Environmental Exposure Effects on Composite Materials for Commercial Aircraft", NASA-15148, Ninth Quarterly Progress Report, NASA CR-165649.

10. "Environmental Exposure Effects on Composite Materials for Commercial Aircraft", NASA-15148, Tenth Quarterly Progress Report, NASA CR-165765.

11. "Environmental Exposure Effects on Composite Materials for Commercial Aircraft", NASA-15148, Eleventh Quarterly Progress Report, NASA CR-165845.

12. "Environmental Exposure Effects on Composite Materials for Commercial Aircraft", NASA-15148, Twelfth Quarterly Progress Report.

13. "Environmental Exposure Effects on Composite Materials for Commercial Aircraft", NASA-15148, Thirteenth Quarterly Progress Report.

14. Springer, George S., and Loos, Alfred C., "Moisture Absorption of Graphite-Epoxy Composites Immersed in Liquids and in Humid Air", Journal of Composite Materials, Vol. 13 (April 1979), p. 131.

APPENDIX A

Individual Specimen Test Data

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LIST OF TABLES

C	T4	N	N	07

1) MATERIAL

A = 5208
B = 5209
C = 934
D = AS-1/3501-6
E = 49/F161-188

2) SPECIMEN CONFIGURATION

SE = Short beam extended (3 specimens)
SB = Short beam shear
FL = Flexure
T4 = $\pm$45 tension
T0 = 0 tension
T9 = 90 tension
TQ = Quasi isotropic tension
C0 = 0 compression
C9 = 90 compression
CQ = Quasi isotropic compression

3) GEOGRAPHICAL LOCATION

P = Southwest Airlines
A = Aloha Airlines
F = Air New Zealand
N = Dallas, Texas
E = Edwards AFB
D = Wellington, New Zealand
H = Honolulu, Hawaii
L = Laboratory
blank = Excess and unassigned

4) LOCAL EXPOSURE LOCATION AND CONDITION

S = Solar
N = Nonsolar
I = Interior (Task II)
B = Baseline and temperature
T = Time effects
M = Moisture effects
2 = Time and stress
G = Ground-air-ground cycling
W = Weatherometer
F = Slow cycle fatigue
blank = Excess and unassigned

5) EXPOSURE DURATION

00 = 0 year nominal
0A = 1 month nominal
0B = 2 month nominal
0C = 3 month nominal
0F = 6 month nominal
0I = 9 month nominal
01 = 1 year nonimal
02 = 2 year nominal
03 = 3 year nominal
05 = 5 year nominal
07 = 7 year nominal
10 = 10 year nominal
blank = Excess and unassigned

* material 934, $\pm$45 tension, Dallas (ground rack), nonsolar, and exposed for 7 years.

FIGURE A-1 SPECIMEN NUMBERING SYSTEM

Table A-1. Physical and Mechanical Test Data, Edwards AFB 3 Year Solar Specimens.

IDENTIFYING CHARACTERS	LAMINATE THICKNESS (IN)	LAMINATE WIDTH (IN)	INITIAL DRY LAMINATE WEIGHT (GRAM)	INITIAL DRY SPECIMEN WEIGHT (GRAM)	EXPOSED SPECIMEN WEIGHT (GRAM)	FINAL DRY SPECIMEN WEIGHT (GRAM)	ULTIMATE FAILURE LOAD (POUND)	ULTIMATE FAILURE STRESS (PSI)	TEST TEMPERATURE (F)
ASEES03-01	.0989	.2494	1.3657	1.4856	1.4859		455.30	13844.	72.0
ASEES03-02	.0963	.2498	1.3253	1.4733	1.4742		377.70	11776.	180.0
ASEES03-03	.0964	.2447	1.2944	1.4482	1.4489				180.0
AFLES03-01	.0671	.4966	1.7900	2.0517	2.0494		158.00	270894.	72.0
AFLES03-02	.0669	.4950	1.7391	1.9870	1.9839		155.00	268008.	72.0
AFLES03-03	.0662	.4986	1.7844	2.0607	2.0573		156.00	273482.	72.0
AFLES03-04	.0670	.4923	1.7375	1.9928	1.9887		133.00	230539.	180.0
AFLES03-05	.0663	.4966	1.7821	2.0410	2.0361		154.50	271124.	180.0
AFLES03-06	.0661	.4965	1.7577	2.0299	2.0263		146.75	259137.	180.0
AT4ES03-01	.0433	1.0025	9.0513	10.8390	10.8143		1115.00	25686.	72.0
AT4ES03-02	.0431	1.0036	9.0721	10.9398	10.9101		1115.00	25777.	72.0
AT4ES03-03	.0415	1.0033	9.0179	10.8234	10.7893		1085.00	26059.	72.0
AT4ES03-04	.0428	.9990	8.9262	10.8772	10.6452		855.00	19997.	180.0
AT4ES03-05	.0436	1.0023	8.9545	10.7656	10.7385		870.00	19908.	180.0
AT4ES03-06	.0421	1.0018	9.0626	10.8889	10.8625		875.00	20747.	180.0
BSEES03-01	.1026	.2478	1.3710	1.5014	1.5016		423.00	12478.	72.0
BSEES03-02	.1022	.2499	1.4228	1.5639	1.5642		277.30	8143.	180.0
BSEES03-03	.1033	.2462	1.3589	1.4927	1.4929				180.0
BFLES03-01	.0630	.4950	1.6517	1.9473	1.9411		139.00	272508.	42.0
BFLES03-02	.0638	.4905	1.6470	1.9322	1.9263		141.50	272977.	72.0
BFLES03-03	.0638	.4946	1.6587	1.9474	1.9422		118.00	225755.	72.0
BFLES03-04	.0635	.4915	1.6434	1.9256	1.9207		118.50	224472.	180.0
BFLES03-05	.0632	.4984	1.6760	1.9569	1.9511		126.00	243786.	180.0
BFLES03-06	.0624	.4978	1.6582	1.9438	1.9389		105.75	210139.	180.0
BT4ES03-01	.0458	1.0010	9.6156	11.3741	11.3593		1340.00	29228.	72.0
BT4ES03-02	.0467	1.0016	9.7741	11.6648	11.6462		1380.00	29503.	72.0
BT4ES03-03	.0470	.9983	9.7575	11.6541	11.6245		1385.00	29518.	72.0
BT4ES02-04	.0451	1.0014	9.5264	11.4239	11.4005		1190.00	26349.	180.0
BT4ES03-05	.0465	1.0030	9.7557	11.5959	11.5752		1235.00	26480.	180.0
BT4ES03-06	.0448	1.0020	9.5451	11.3885	11.3683		1200.00	26732.	180.0
CSEES03-01	.1090	.2496	1.4958	1.6807	1.6818		530.00	14611.	72.0
CSEES03-02	.1089	.2493	1.4893	1.6777	1.6784		395.30	10920.	180.0
CSEES03-03	.1059	.2508	1.4542	1.6379	1.6388				180.0
CFLES03-01	.0671	.4993	1.8029	2.0606	2.0567		159.25	267800.	72.0
CFLES03-02	.0677	.4973	1.8247	2.0885	2.0861		166.75	276571.	72.0
CFLES03-03	.0677	.5001	1.8000	2.0462	2.0437		171.00	282032.	72.0
CFLES03-04	.0642	.4957	1.6911	1.9387	1.9343		124.25	229903.	180.0
CFLES03-05	.0628	.4964	1.6864	1.9466	1.9411		129.75	250549.	180.0
CFLES03-06	.0646	.4980	1.7321	2.0070	2.0008		141.50	257395.	180.0
CT4ES03-01	.0462	1.0021	9.8526	11.8409	11.8231		1150.00	24840.	72.0
CT4ES03-02	.0468	1.0022	9.8374	11.8525	11.8328		1185.00	25265.	72.0
CT4ES03-03	.0461	1.0023	9.8119	11.9238	11.8981		1170.00	25321.	72.0
CT4ES03-04	.0445	1.0014	9.7653	11.7988	11.7754		1085.00	24348.	180.0
CT4ES03-05	.0465	1.0000	9.8635	11.8951	11.8726		1065.00	22903.	180.0
CT4ES03-06	.0478	1.0054	9.9452	11.8431	11.8237		1100.00	22889.	180.0

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Table A-2. Physical and Mechanical Test Data, Edwards AFB 3 Year Nonsolar Specimens.

IDENTIFYING CHARACTERS	LAMINATE THICKNESS (IN)	LAMINATE WIDTH (IN)	INITIAL DRY LAMINATE WEIGHT (GRAM)	INITIAL DRY SPECIMEN WEIGHT (GRAM)	EXPOSED SPECIMEN WEIGHT (GRAM)	FINAL DRY SPECIMEN WEIGHT (GRAM)	ULTIMATE FAILURE LOAD (POUND)	ULTIMATE FAILURE STRESS (PSI)	TEST TEMPERATURE (F)
ASEEN03-01	.0962	.2506	1.2944	1.4520	1.4528		408.00	12693.	72.0
ASEEN03-02	.0967	.2503	1.3333	1.4862	1.4874		378.30	11722.	180.0
ASEEN03-03	.0955	.2492	1.3121	1.4712	1.4722				180.0
AFLEN03-01	.0668	.4984	1.7637	2.0494	2.0462		145.00	249753.	72.0
AFLEN03-02	.0672	.4967	1.7568	2.0466	2.0442		146.50	250195.	72.0
AFLEN03-03	.0669	.4977	1.7620	2.0416	2.0386		151.00	259875.	72.0
AFLEN03-04	.0667	.4984	1.7868	2.0728	2.0718		150.25	259572.	180.0
AFLEN03-05	.0668	.4920	1.7350	2.0052	2.0035		148.50	259108.	180.0
AFLEN03-06	.0666	.4961	1.7353	2.0476	2.0462		145.00	252929.	180.0
AT4EN03-01	.0468	.9976		26.1917	26.2025		1000.00	21419.	180.0
AT4EN03-02	.0467	.9977		25.9081	25.9192		915.00	19638.	180.0
AT4EN03-03	.0457	.9957		25.8653	25.8762		985.00	21647.	180.0
ACOEN03-01	.1000	.2480					6975.00	281250.	72.0
ACOEN03-02	.1072	.2476					4400.00	165637.	72.0
ACOEN03-03	.1021	.2476					5375.00	212619.	72.0
ACOEN03-04	.1033	.2464					2750.00	108042.	180.0
ACOEN03-05	.1026	.2459					3600.00	142601.	180.0
ACOEN03-06	.1010	.2402					3475.00	143239.	180.0
BSEEN03-01	.1045	.2430	1.3691	1.5446	1.5400		416.70	12307.	72.0
BSEEN03-02	.1030	.2433	1.3525	1.5094	1.5088		267.30	8606.	180.0
BSEEN03-03	.1027	.2482	1.3765	1.5451	1.5399				180.0
BFLEN03-01	.0648	.4966	1.6842	1.9870	1.9815		155.00	286393.	72.0
BFLEN03-02	.0638	.4981	1.6733	1.9732	1.9683		147.50	280211.	72.0
BFLEN03-03	.0640	.4982	1.6714	1.9727	1.9681		138.60	261419.	72.0
BFLEN03-04	.0632	.4984	1.6846	1.9983	1.9918		120.60	233144.	180.0
BFLEN03-05	.0629	.4956	1.6442	1.9475	1.9432		117.50	230811.	180.0
BFLEN03-06	.0640	.4966	1.6778	1.9806	1.9757		110.25	208767.	180.0
BT4EN03-01	.0426	1.0048		25.3834	25.3661		1005.00	23479.	180.0
BT4EN03-02	.0427	1.0007		25.5453	25.5267		1035.00	24222.	180.0
BT4EN03-03	.0427	.9988		25.6484	25.6279		1080.00	25323.	180.0
BCOEN03-01	.1032	.2491					5900.00	229506.	72.0
BCOEN03-02	.1017	.2520					4625.00	180464.	72.0
BCOEN03-03	.1009	.2495					5300.00	210630.	72.0
BCOEN03-04	.1008	.2497					4225.00	167860.	180.0
BCOEN03-05	.1010	.2507					4250.00	167847.	180.0
BCOEN03-06	.1020	.2507					3725.00	145671.	180.0

Table A-2. Physical and Mechanical Test Data, Edwards AFB 3 Year Nonsolar Specimens (Concluded).

IDENTIFYING CHARACTERS	LAMINATE THICKNESS (IN)	LAMINATE WIDTH (IN)	INITIAL DRY LAMINATE WEIGHT (GRAM)	INITIAL DRY SPECIMEN WEIGHT (GRAM)	EXPOSED SPECIMEN WEIGHT (GRAM)	FINAL DRY SPECIMEN WEIGHT (GRAM)	ULTIMATE FAILURE LOAD (POUND)	ULTIMATE FAILURE STRESS (PSI)	TEST TEMPERATURE (F)
CSEEN03-01	.1105	.2490	1.5136	1.6762	1.6780		545.00	14858.	72.0
CSEEN03-02	.1103	.2471	1.5031	1.6610	1.6626		401.70	11054.	180.0
CSEEN03-03	.1055	.2490	1.4411	1.5955	1.5982				180.0
CFLEN03-01	.0665	.4993	1.7688	2.0404	2.0369		160.00	273938.	72.0
CFLEN03-02	.0664	.4990	1.7619	2.0338	2.0299		159.50	274070.	72.0
CFLEN03-03	.0667	.4987	1.7777	2.0612	2.0573		164.25	270867.	72.0
CFLEN03-04	.0656	.4965	1.7695	2.0371	2.0337		144.00	254784.	180.0
CFLEN03-05	.0666	.4972	1.7933	2.0516	2.0483		154.75	265270.	180.0
CFLEN03-06	.0675	.4924	1.7576	2.0100	2.0062		148.25	249808.	180.0
CT4EN03-01	.0472	1.0016		26.3776	26.3776		1190.00	25172.	180.0
CT4EN03-02	.0488	1.0022		26.4650	26.4681		1185.00	24229.	180.0
CT4EN03-03	.0452	1.0028		26.0206	26.0105		1305.00	28791.	180.0
CCOEN03-01	.0937	.2489					5550.00	237973.	72.0
CCOEN03-02	.1012	.2503					6900.00	272400.	72.0
CCOEN03-03	.1045	.2529					6350.00	240275.	72.0
CCOEN03-04	.1060	.2499					5525.00	208574.	180.0
CCOEN03-05	.1085	.2505					4950.00	182124.	180.0
CCOEN03-06	.1021	.2457					4650.00	185363.	180.0

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Table A-3. Physical and Mechanical Test Data, Honolulu 3 Year Solar Specimens.

IDENTIFYING CHARACTERS	LAMINATE THICKNESS (IN)	LAMINATE WIDTH (IN)	INITIAL DRY LAMINATE WEIGHT (GRAM)	INITIAL DRY SPECIMEN WEIGHT (GRAM)	EXPOSED SPECIMEN WEIGHT (GRAM)	FINAL DRY SPECIMEN WEIGHT (GRAM)	ULTIMATE FAILURE LOAD (POUND)	ULTIMATE FAILURE STRESS (PSI)	TEST TEMPERATURE (F)
ASEHS03-01	.0937	.2478	1.2693	1.3987	1.4065		442.30	14287.	72.0
ASEHS03-02	.0968	.2477	1.3170	1.4486	1.4556		310.70	9719.	180.0
ASEHS03-03	.0984	.2517	1.2851	1.4054	1.4120				180.0
AFLHS03-01	.0863	.4998	1.7636	2.0803	2.0854		124.50	217080.	72.0
AFLHS03-02	.0856	.4971	1.7693	2.0537	2.0575		119.25	213540.	72.0
AFLHS03-03	.0859	.4988	1.7739	2.0520	2.0554		110.25	194984.	72.0
AFLHS03-04	.0871	.4978	1.7723	2.0725	2.0763		133.25	227740.	180.0
AFLHS03-05	.0861	.4982	1.7564	2.0441	2.0479		103.00	181981.	180.0
AFLHS03-06	.0874	.4989	1.7845	2.0847	2.0917		114.50	193529.	180.0
AT4HS03-01	.0457	1.0015	9.6316	11.6311	11.6058		1130.00	24889.	72.0
AT4HS03-02	.0453	.9999	9.8178	10.8768	10.8391		1010.00	22298.	72.0
AT4HS03-03	.0468	1.0042	9.6562	11.4677	11.4419		1165.00	24789.	72.0
AT4HS03-04	.0458	1.0012	9.6325	11.4659	11.4421		1160.00	25297.	180.0
AT4HS03-05	.0458	1.0007	9.6596	11.8487	11.8136		1120.00	24437.	180.0
AT4HS03-06	.0458	1.0035	9.6781	11.6606	11.6275		1160.00	25239.	180.0
BSEHS03-01	.1031	.2467	1.3704	1.5290	1.5239		368.67	10871.	72.0
BSEHS03-02	.1025	.2406	1.3264	1.4771	1.4826		206.00	8265.	180.0
BSEHS03-03	.1018	.2487	1.4055	1.5663	1.5689				180.0
BFLHS03-01	.0818	.4924	1.6508	1.8846	1.8862		94.75	194059.	72.0
BFLHS03-02	.0821	.4939	1.6553	1.9084	1.9085		109.75	221938.	72.0
BFLHS03-03	.0830	.4965	1.6636	1.9076	1.9074		121.75	237968.	72.0
BFLHS03-04	.0835	.4968	1.6784	1.9252	1.9265		85.25	163914.	180.0
BFLHS03-05	.0828	.4928	1.6501	1.8955	1.8962		76.75	152103.	180.0
BFLHS03-06	.0821	.4906	1.6371	1.8800	1.8802		68.25	138945.	180.0
BT4HS03-01	.0440	1.0028	9.0954	11.3144	11.2658		1070.00	24250.	72.0
BT4HS03-02	.0446	1.0021	9.3128	11.5305	11.4826		1180.00	26402.	72.0
BT4HS03-03	.0446	1.0013	9.2891	10.9981	10.9625		1215.00	27207.	72.0
BT4HS03-04	.0445	1.0000	9.3310	10.9258	10.8906		855.00	19213.	180.0
BT4HS03-05	.0439	1.0037	9.3115	10.8124	10.7782		920.00	20879.	180.0
BT4HS03-06	.0451	.9995	9.2280	11.0580	11.0259		970.00	21519.	180.0
CSEHS03-01	.1084	.2507	1.4789	1.6352	1.6438		464.33	12815.	72.0
CSEHS03-02	.1084	.2503	1.4799	1.6323	1.6413		331.33	9159.	180.0
CSEHS03-03	.1096	.2480	1.4782	1.6338	1.6408				180.0
CFLHS03-01	.0866	.4953	1.7898	2.0639	2.0694		117.50	202189.	72.0
CFLHS03-02	.0860	.5003	1.7565	2.0393	2.0446		122.50	212498.	72.0
CFLHS03-03	.0862	.4992	1.7709	2.0374	2.0415		116.75	201745.	72.0
CFLHS03-04	.0870	.5016	1.8129	2.0970	2.1022		132.50	222457.	180.0
CFLHS03-05	.0869	.4982	1.8052	2.0812	2.0864		124.75	212139.	180.0
CFLHS03-06	.0852	.4974	1.7352	2.0012	2.0058		109.75	196219.	180.0
CT4HS03-01	.0453	1.0037	9.8531	11.9474	11.9207		1135.00	24963.	72.0
CT4HS03-02	.0452	1.0044	9.8345	11.9532	11.9282		1125.00	24780.	72.0
CT4HS03-03	.0459	.9973	9.7582	11.9011	11.8704		1130.00	24685.	72.0
CT4HS03-04	.0465	.9996	9.7242	11.8917	11.8578		1180.00	25386.	180.0
CT4HS03-05	.0465	.9982	9.7046	11.8638	11.8324		1285.00	27684.	180.0
CT4HS03-06	.0459	1.0024	9.8000	11.9060	11.8965		1080.00	23473.	180.0

Table A-4. Physical and Mechanical Test Data, Honolulu 3 Year Nonsolar Specimens.

IDENTIFYING CHARACTERS	LAMINATE THICKNESS (IN)	LAMINATE WIDTH (IN)	INITIAL DRY LAMINATE WEIGHT (GRAM)	INITIAL DRY SPECIMEN WEIGHT (GRAM)	EXPOSED SPECIMEN WEIGHT (GRAM)	FINAL DRY SPECIMEN WEIGHT (GRAM)	ULTIMATE FAILURE LOAD (POUND)	ULTIMATE FAILURE STRESS (PSI)	TEST TEMPERATURE (F)
ASEHN03-01	.0977	.2497	1.3255	1.4685	1.4764		460.00	14142.	72.0
ASEHN03-02	.1029	.2494	1.4032	1.5461	1.5547		357.00	10433.	180.0
ASEHN03-03	.0972	.2493	1.3234	1.4698	1.4780				180.0
AFLHN03-01	.0669	.4962	1.7634	2.0543	2.0625		134.50	231999.	72.0
AFLHN03-02	.0671	.4989	1.7842	2.0805	2.0885		137.75	234912.	72.0
AFLHN03-03	.0678	.4950	1.7741	2.0527	2.0607		151.75	255468.	72.0
AFLHN03-04	.0662	.4945	1.7520	2.0438	2.0524		114.75	202835.	180.0
AFLHN03-05	.0675	.4942	1.7564	2.0378	2.0458		144.75	246253.	180.0
AFLHN03-06	.0652	.4991	1.7513	2.0721	2.0795		129.50	233808.	180.0
AT4HN03-01	.0458	1.0003		25.7186	25.7790		1130.00	24665.	180.0
AT4HN03-02	.0456	.9992		25.7980	25.8021		970.00	21289.	180.0
AT4HN03-03	.0463	.9996		25.7543	25.8216		1155.00	24956.	180.0
ACOHN03-01	.1060	.2452					3625.00	139470.	72.0
ACOHN03-02	.1060	.2480					4575.00	174034.	72.0
ACOHN03-03	.1012	.2471					6050.00	241937.	72.0
ACOHN03-04	.1014	.2433					1125.00	45601.	180.0
ACOHN03-05	.1039	.2440					1050.00	41418.	180.0
ACOHN03-06	.0994	.2402					775.00	32460.	180.0
BSEHN03-01	.1024	.2463	1.3730	1.5198	1.5259		582.00	11360.	72.0
BSEHN03-02	.1031	.2458	1.3902	1.5351	1.5408		208.67	8176.	180.0
BSEHN03-03	.1021	.2518	1.3920	1.5273	1.5342				180.0
BFLHN03-01	.0626	.4931	1.6646	1.9427	1.9460		109.75	218762.	72.0
BFLHN03-02	.0636	.4910	1.6616	1.9078	1.9126		106.00	209449.	72.0
BFLHN03-03	.0631	.4912	1.6540	1.9173	1.9204		89.00	157552.	72.0
BFLHN03-04	.0639	.4971	1.6666	1.9263	1.9305		90.25	171258.	180.0
BFLHN03-05	.0627	.4986	1.6794	1.9329	1.9374		99.00	194535.	180.0
BFLHN03-06	.0625	.4973	1.6690	1.9207	1.9252		87.75	173988.	180.0
BT4HN03-01	.0429	.9965		24.6165	24.6445		1015.00	23743.	180.0
BT4HN03-02	.0432	1.0029		24.4140	24.4459		1020.00	23543.	180.0
BT4HN03-03	.0436	1.0028		24.4289	24.4630		1160.00	26531.	180.0
BCOHN03-01	.1057	.2497					6175.00	233961.	72.0
BCOHN03-02	.1027	.2500					5775.00	224927.	72.0
BCOHN03-03	.1042	.2501					5375.00	206251.	72.0
BCOHN03-04	.1017	.2493					2900.00	114381.	180.0
BCOHN03-05	.1016	.2507					2375.00	93243.	180.0
BCOHN03-06	.1011	.2509					2650.00	104471.	180.0

Table A-4. Physical and Mechanical Test Data, Honolulu 3 Year Nonsolar Specimens (Concluded).

IDENTIFYING CHARACTERS	LAMINATE THICKNESS (IN)	LAMINATE WIDTH (IN)	INITIAL DRY LAMINATE WEIGHT (GRAM)	INITIAL DRY SPECIMEN WEIGHT (GRAM)	EXPOSED SPECIMEN WEIGHT (GRAM)	FINAL DRY SPECIMEN WEIGHT (GRAM)	ULTIMATE FAILURE LOAD (POUND)	ULTIMATE FAILURE STRESS (PSI)	TEST TEMPERATURE (F)
CSEHN03-01	.1138	.2472	1.5020	1.6510	1.6612		409.33	12513.	72.0
CSEHN03-02	.1100	.2482	1.5022	1.6645	1.6752		327.33	8992.	180.0
CSEHN03-03	.1091	.2487	1.4864	1.6525	1.6631				180.0
CFLHN03-01	.0661	.4994	1.7730	2.0806	2.0882		135.00	233894.	72.0
CFLHN03-02	.0683	.4987	1.8352	2.1147	2.1233		134.50	218564.	72.0
CFLHN03-03	.0675	.5017	1.8090	2.1045	2.1126		130.25	215409.	72.0
CFLHN03-04	.0667	.4975	1.7900	2.0863	2.0947		111.25	190017.	180.0
CFLHN03-05	.0673	.5009	1.8190	2.1202	2.1206		136.25	227035.	180.0
CFLHN03-06	.0644	.4993	1.7305	2.0357	2.0128		126.25	230481.	180.0
CT4HN03-01	.0468	1.0020		25.8474	25.9087		1280.00	27296.	180.0
CT4HN03-02	.0478	1.0014		26.4299	26.4931		1285.00	26845.	180.0
CT4HN03-03	.0446	1.0012		25.9647	26.0248		1265.00	28329.	180.0
CCOHN03-01	.1072	.2495					5975.00	223395.	72.0
CCOHN03-02	.1056	.2485					6275.00	239124.	72.0
CCOHN03-03	.1059	.2502					5450.00	205690.	72.0
CCOHN03-04	.1033	.2491					3000.00	116686.	180.0
CCOHN03-05	.0974	.2504					3440.00	141047.	180.0
CCOHN03-06	.1047	.2503					4300.00	164082.	180.0

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Table A-5. Physical and Mechanical Test Data, 3 Year Time Alone Short Beam Shear Specimens.

IDENTIFYING CHARACTERS	LAMINATE THICKNESS (IN)	LAMINATE WIDTH (IN)	INITIAL DRY LAMINATE WEIGHT (GRAM)	INITIAL DRY SPECIMEN WEIGHT (GRAM)	EXPOSED SPECIMEN WEIGHT (GRAM)	FINAL DRY SPECIMEN WEIGHT (GRAM)	ULTIMATE FAILURE LOAD (POUND)	ULTIMATE FAILURE STRESS (PSI)	TEST TEMPERATURE (F)
ASBLT03-01	.0961	.2480					474.00	14916.	72.0
ASBLT03-02	.0958	.2489					533.00	16698.	72.0
ASBLT03-03	.0968	.2496					518.00	16079.	72.0
ASBLT03-04	.0965	.2490					582.00	17542.	72.0
ASBLT03-05	.0979	.2455					410.00	12794.	72.0
ASBLT03-06	.0974	.2516					389.00	11905.	180.0
ASBLT03-07	.0971	.2487					414.00	12858.	180.0
ASBLT03-08	.0980	.2505					418.00	12709.	180.0
ASBLT03-09	.0981	.2489					428.00	13147.	180.0
ASBLT03-10	.0970	.2515	4.1991		4.1976		383.00	11160.	180.0
BSBLT03-01	.1030	.2480					437.00	12831.	72.0
BSBLT03-02	.1029	.2509					440.00	12782.	72.0
BSBLT03-03	.1031	.2490					429.00	12533.	72.0
BSBLT03-04	.1040	.2512					442.00	12689.	72.0
BSBLT03-05	.1018	.2528					429.00	12490.	72.0
BSBLT03-06	.1033	.2498					306.00	8894.	180.0
BSBLT03-07	.1022	.2483					309.00	9114.	180.0
BSBLT03-08	.1048	.2502					303.00	8667.	180.0
BSBLT03-09	.1028	.2497					301.00	8795.	180.0
BSBLT03-10	.1031	.2434	4.4143		4.4174		297.00	8878.	180.0
CSBLT03-01	.1058	.2494					522.00	14837.	72.0
CSBLT03-02	.1123	.2504					515.00	13738.	72.0
CSBLT03-03	.1090	.2430					523.00	14809.	72.0
CSBLT03-04	.1100	.2495					540.00	14757.	72.0
CSBLT03-05	.1100	.2511					552.00	14989.	72.0
CSBLT03-06	.1101	.2500					428.00	11662.	180.0
CSBLT03-07	.1108	.2501					445.00	12044.	180.0
CSBLT03-08	.1147	.2480					441.00	11627.	180.0
CSBLT03-09	.1110	.2507					443.00	11940.	180.0
CSBLT03-10	.1136	.2513	4.8307		4.8270		435.00	11428.	180.0

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Table A-6. Physical and Mechanical Test Data, 3 Year Time Alone Flexure Specimens.

IDENTIFYING CHARACTERS	LAMINATE THICKNESS (IN)	LAMINATE WIDTH (IN)	INITIAL DRY LAMINATE WEIGHT (GRAM)	INITIAL DRY SPECIMEN WEIGHT (GRAM)	EXPOSED SPECIMEN WEIGHT (GRAM)	FINAL DRY SPECIMEN WEIGHT (GRAM)	ULTIMATE FAILURE LOAD (POUND)	ULTIMATE FAILURE STRESS (PSI)	TEST TEMPERATURE (F)
AFLLT03-01	.0665	.5000					106.25	184072.	72.0
AFLLT03-02	.0670	.4999					117.00	199722.	72.0
AFLLT03-03	.0673	.5038					133.50	224112.	72.0
AFLLT03-04	.0682	.5028					110.75	181406.	72.0
AFLLT03-05	.0673	.5011					124.25	209708.	72.0
AFLLT03-06	.0674	.5028					131.50	220538.	180.9
AFLLT03-07	.0680	.4993					117.50	194954.	180.0
AFLLT03-08	.0680	.4997					103.50	171588.	180.0
AFLLT03-09	.0670	.5020					103.75	176363.	180.0
AFLLT03-10	.0668	.5029	17.8356		17.8163		97.25	166008.	180.0
BFLLT03-01	.0639	.4962					106.75	202936.	72.0
BFLLT03-02	.0635	.4959					83.50	160840.	72.0
BFLLT03-03	.0648	.4962					101.00	186709.	72.0
BFLLT03-04	.0635	.4989					98.25	188114.	72.0
BFLLT03-05	.0632	.4960					97.00	188585.	72.0
BFLLT03-06	.0640	.4965					107.75	204074.	180.0
BFLLT03-07	.0634	.4979					101.50	195342.	180.0
BFLLT03-08	.0640	.4988					110.50	208318.	180.0
BFLLT03-09	.0642	.4962					111.75	210461.	180.0
BFLLT03-10	.0635	.4925	16.6887		16.6723		107.50	208500.	180.0
CFLLT03-01	.0677	.5000					146.00	240848.	72.0
CFLLT03-02	.0670	.4945					134.75	229483.	72.0
CFLLT03-03	.0672	.4982					114.75	192818.	72.0
CFLLT03-04	.0655	.5000					108.00	190330.	72.0
CFLLT03-05	.0670	.4990					106.25	179315.	72.0
CFLLT03-06	.0683	.4989					108.50	176243.	180.0
CFLLT03-07	.0677	.4998					94.50	155954.	180.0
CFLLT03-08	.0680	.5005					118.00	192751.	180.0
CFLLT03-09	.0680	.4982					140.75	230975.	180.0
CFLLT03-10	.0653	.5009	17.7782		17.7546		96.25	170357.	180.0

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